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FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by R. W. V. PALMER

VOLUME XXIV : NUMBER 1

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1951

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CONTENTS

Speedier Rehabilitation of English Woodlands. By O. J. SANGAR . . 1
A Fallacy in the Theory of Growing Stock. By R. BOURNE . . . 6
The Possibilities of Improving Forest Trees (*with Plate I*). By C. SYRACH LARSEN 19
A Study of Growth Rings in Trees. By C. G. DOBBS 22
A Century-old Forest Nursery in Germany (*with Plate II*). By BLANCHE BENZIAN 36
The Susceptibility to Injury by Experimental Freezing of Strains of European Larch (*Larix decidua* Mill.) of Varying Geographical Origin. By W. R. DAY 39
English Tree Names and their Origins. By H. L. EDLIN 57
Society's and Other News 64
Obituary. The Late Sir Alexander Rodger, O.B.E. 65
Excursion to Argyll 65

REVIEWS

Anatomy of the Dicotyledons, Leaves, Stem and Wood, in Relation to Taxonomy (C. R. METCALFE and L. CHALK). By B. J. RENDLE . . 69
Northern Coniferous Forest Soils (OLOF TAMM, translated from the Swedish by M. L. ANDERSON). By G. K. FRASER 70
Forest Types and Their Significance (A. K. CAJANDER). By M. L. ANDERSON 72
The Selection of Tree Species (M. L. ANDERSON). By J. A. B. MACDONALD . 73
Textbook of Dendrology, covering the Important Forest Trees of the United States and Canada (W. H. HARLOW and E. S. HARRAR). By F. K. MAKINS 76

NOTICES

Journal of Forestry. Vol. 48, No. II. November 1950 78
Journal of the Oxford University Forest Society. Michaelmas Term 1950. Third Series. No. 5 78

SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed at Aberdeen in 1925 and adopted its first Constitution at Oxford in 1926. This has been modified several times and the present Constitution became operative in December 1947.

The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects.

The activities include the publication of the journal, the holding of meetings, conferences, and excursions, and the awarding of a medal.

The membership is divided into four classes, the respective qualifications being as outlined below:

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THE SOCIETY AND ITS JOURNAL

THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in June and December. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to R. W. V. Palmer, Bannerleigh, Leigh Woods, Bristol. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should begin with a summary which should be factual and convey briefly the content of the article and draw attention to all new information and to the main conclusions. It should be concise and should not normally exceed 200 words. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

Forestry is sent free to members of the Society; others may register as subscribers by application to the Secretary, R. Angus Galloway, 7 Albyn Place, Edinburgh, 2.

SOCIETY'S MEDAL. This may be awarded by the Society to any individual who has rendered eminent services to British forestry. Proposals for the award have to be made in the first instance to the Council by a Member of the Council. The regulations for the award will be found in Vol. XX, pp. 80, 81, and in Rule 11.

NOTICE

The Index to Volumes XI to XX is now ready and is being distributed to subscribers together with this number.

The price of the Index to others is ten shillings and copies may be had on application to The Clarendon Press, Oxford.

SPEEDIER REHABILITATION OF ENGLISH WOODLANDS

(Presidential Address to the Society of Foresters of Great Britain, at Oban, September 1950)

By O. J. SANGAR

(Forestry Commission)

SUMMARY.

The present and probable future rate of progress under current procedure is discussed and methods by which the work could be expedited are examined. Material improvement should result from the adoption in suitable cases of revised silvicultural practices specially adapted to the conservation of existing growth and to the employment of less labour per acre than the practice of clearing and replanting. A considerable but unknown proportion of the area concerned now carries growth which can be converted, with great economy of labour, into useful hardwood or mixed stands, even though carrying relatively few stems per acre. In those many cases where existing growth is already of an appreciable age, such conversion, coupled with any suitable enrichment, would make an especially valuable contribution to the acreage of those age-classes which are the most deficient, particularly in hardwoods. It is also the only means by which many of the smaller woods can economically be made productive. Much evidence is available from past work on these lines. It is urgently necessary to analyse and apply results achieved to date and to initiate research to fill gaps in our knowledge, particularly in relation to pruning and free-growth, also as to the timber-quality of fast grown trees.

MORE and more attention is being directed to the many and complex problems involved in restoring the English woodlands to a reasonably productive state, but it is nevertheless doubful whether there is sufficient appreciation of the time factor involved. A most useful summary of the present situation is contained in a paper presented by Mr. R. F. Wood (2) to the United Nations Scientific Conference at Lake Success in 1949 and printed in the *Quarterly Journal of Forestry* in January 1950. As there pointed out, the recent census shows that there are in England 543,200 acres of woodland which are reported as in need of speedy regeneration; in addition to this area, a very considerable proportion of the 321,000 acres classed as coppice or coppice with standards must undoubtedly be converted to some other form of silviculture if it is to be made reasonably productive. Assuming that replanting during the 3 years which have elapsed since the census compensates for the felling in that period, it is fair to say that there are some 600,000 acres of woodland in England which today need attention, and need it urgently.

By their joint efforts the Forestry Commission and private owners are now dealing with the clearing and replanting of some 15,000 acres of woodland areas *per annum*; the rate of progress is governed as much by labour supply as by finance and only to a minor extent by the shortage of suitable plants. Whatever arrangements may be made in other respects, labour supply will remain a limiting factor;

we have no justification for assuming that new housing and other measures will so increase the labour available for this work that it will be possible by conventional methods to deal with an average of more than 20,000 acres of woodland areas *per annum* over the next 6 or 7 years. Felling must necessarily continue meantime; no close estimate of the area which will be felled annually is possible, but it would seem unwise to assume that it will be less than 10,000 acres, i.e. half the probable annual rate of replanting. It is thus necessary to face a position in which the 600,000 acres requiring attention are replanted at a net rate which does not exceed about 10,000 acres *per annum*. These figures as to rate of progress are of necessity speculative, but it is clearly probable that under present procedure the area of woodland urgently in need of regeneration 10 years hence will be not less than half a million acres, much of it then carrying either woody regrowth or a mass of tangled and often worthless rubbish 10 years older than it is today.

The urgent need is to grow the maximum quantity of timber to the requisite specification in the shortest possible time; over an undetermined proportion of 600,000 acres of felled and devastated woodland and coppice we have already 5, 10, or 20 years' growth; if this growth can be made use of, we are not justified in destroying it. With some departure from current practices as to spacing and methods of regeneration, coupled with the acceptance of the principles of green pruning and free-growth, it should be possible to produce over a much larger area, and more quickly than by conventional methods, a specification which is required most urgently, that is to say, logs suitable for saw timber in utilizable (if not optimum) lengths. It should also be possible to secure that in years to come there will be a minimum area of elderly unimproved rubbish which, by intelligent earlier attention, could have been made into something useful. Broadly, the techniques which must be developed are such as will result in a high economy in labour and ancillary costs, but these will unfortunately make heavy demands upon skilled supervision. The aim must be to secure that economies in labour permit a greater acreage to be brought under proper management rather than that the total expenditure shall be reduced; if in due course improved technique secures financial economies, savings should be used for dealing with larger and yet larger areas. It would be illogical to use existing or future resources on areas which involve a great deal of work, whilst there still exist other areas on which, in the aggregate, greater production can be secured with less work in a shorter time.

In making plans for the best use of the available resources, it is convenient to consider the woodland areas in question in the following three main categories:

Category 1. Felled woodland, now more or less bare of rank vegetation, where straightforward replanting can proceed, and there is a reasonable expectation of a complete stocking of the chosen species.

Category 2. Areas carrying an appreciable stocking of acceptable (but not necessarily optimum) species, as a result of natural regeneration, coppice, or both.

Category 3. Areas where there is dense vegetation, and often forest conditions, but where the stocking of acceptable species is patently unsatisfactory or is entirely absent.

It is not proposed to discuss the first of the above categories, but to consider only the second and the third; both of these include a large proportion of land admirably suited to the growth of hardwoods, and any procedure to make use of existing stocking would have to accept the position that hardwoods would constitute an important proportion of the production. The national need is primarily for softwoods, but on the other hand there is a grievous shortage of hardwoods, particularly in the intermediate age-classes, and experience in the Second World War showed that in an emergency they could be used to a very considerable extent in substitution for softwood.

It is difficult to over-emphasize the importance of the initial examination of areas which may fall into Categories 2 or 3. The problems require, and the issues justify, a close and detailed survey to establish precisely what exists on the ground, quantitatively and qualitatively, and to assess potentialities. In any cases of doubt, the survey should be by random strips and plots, and such surveys require to be undertaken by fully competent individuals.

Areas in the second category will very rarely be wholly satisfactory as regards stocking, form, or distribution of stems, but if it can be arranged to use the existing growth, there will be certain very important advantages in comparison with areas which have been newly cleared and planted. There will, for instance, be no expense incurred for preparation of ground, nor for plants, planting, or weeding; the cost of rabbit-fencing may very likely be avoided and, possibly the greatest advantage of all, these areas will have a certain number of years' growth to their credit and can thus make a special contribution towards the acreage of those age-classes which are, in hardwoods, the most seriously deficient. Some of these advantages are of outstanding importance with small woods, costly to fence, protect, and supervise, where it is clearly difficult to justify the expenditure and difficulties involved in conventional clearing and replanting. The optimum development of the maximum number of available stems of acceptable species and development must be the first objective in all work on existing growth, which may sometimes already be 20 or 30 years old; it will be essential to remove wolf trees and in many cases to undertake cleanings or even thinnings, the green-pruning of desirable stems will frequently be necessary, and the planting of major gaps, possibly using large plants, sleeve-netted or otherwise specially protected against rabbits. Admittedly the intermediate yields may be low and final crops will generally be mixed and frequently irregular, but these features are not necessarily disadvantageous in the achievement of the ultimate objective of the largest aggregate yield of usefully exploitable timber in the shortest possible time.

Under the third category, mention must first be made of sites carrying only thorn (*Cratægus*), yew (*Taxus*), rhododendron, gorse (*Ulex*), bramble (*Rubus*), &c. Such areas must be cleared and replanted, but individual trees (such as yew) should not be cut where the cost is out of all proportion to the area thus made productive, and it is very important to choose the best time for the work and preferably to deal first with types which will give better returns for the same expenditure of labour. The more immediately important problem is that of areas where there is in fact a forest crop but it is for some reason or other not

acceptable. The growth may be coppice of an undesirable species such as hornbeam (*Carpinus*) or of a desirable species, but from old stools or damaged by rabbits, fire, or some other agency; other areas may carry anything from good but overgrown or otherwise unmarketable hazel (*Corylus*) coppice to high forest or young regeneration of birch (*Betula*), ash (*Fraxinus*), or aspen (*Populus*) on doubtfully suitable sites. If the careful initial examination establishes that in fact there is little or nothing worth having, the problem becomes the same as for the areas first mentioned under this third category. On the other hand, many areas will be found to carry a sufficient potential of desirable species even though stocking and form are not, in the ordinary sense, satisfactory; in such cases the avoidance of planting and allied costs, rabbit-fencing, &c., will often justify making the best use of this potential, using labour for filling gaps, underplanting, and for coppicing, thinning, cleaning, and pruning even a relatively few desirable trees. The treatment of these areas must be undertaken only as and when they can be handled most advantageously; the further development of suitable silvicultural techniques by which fewer plants are used and expensive clearance and fencing avoided is necessary, but the urgency of the situation is such that action cannot be deferred pending attempts to reach finality as regards optimum methods. Considerable progress has already been made in methods of strip or group planting and, of course, underplanting, but present methods of strip and group planting still involve the use of a large number of plants and the rabbit-fencing of the area, as well as a good deal of clearance of undergrowth in order to permit rabbit-destruction.

Inquiries cannot suffice if they are focused solely upon the silvicultural aspects of the matter; there must be information as to rate and efficiency of occlusion, quality of timber in wide-ringed open-grown trees, costs and methods of pruning, and many other points. *Ad hoc* research will in due course provide many of the answers, but meantime there is much to be learnt from work already undertaken. Examples of this work include the conversion of coppice to oak/beech (*Quercus*/*Fagus*) high forest, which was started some 40 years ago at Tintern and where there is now an 80-year-old fully stocked crop of clean sound timber of small millable size and giving every indication of continued healthy growth. Prior to the conversion operations these coppices had been maintained for a long time for tanbark and charcoal; healthy, low stools, and a fertile soil combined to give them a comparatively easy start, but they nevertheless provide a clear indication of what could be done on quite a large acreage of old coppice woodland. An outstanding example of work carried out since the fellings of 1939–45 is on Lord Bathurst's property at Cirencester, where the regrowth of ash, sycamore (*Acer*), and other species has already been carefully nursed into a good thicket crop with only the minimum of artificial replanting to fill any really big gaps. Amongst other instances, mention may be made of Ashridge, where the National Trust are, on a smaller scale, converting what might appear to be an ordinary birch jungle into quite a good mixed wood simply by selective cleaning and preservation of the numerous seedling oak, beech, and other timber species which occur in the regrowth and which, without attention, would have suffered complete suppression. The Forestry Commission is at present making investiga-

tions into the growth of oak, and Mr. Hummel's preliminary data make it clear that on first-quality sites, provided the trees have individual growing space throughout their life—and this may, of course, involve green pruning at some stages—it is possible to grow a final crop of 25 to 30 oak-trees of millable size per acre at an age of 80 years. What holds good for oak may well apply to others of our hardwoods.

Foresters cannot tacitly accept the position that, as years go by, the woodlands of England shall remain largely in a condition of decrepitude, with but little decrease in the extent of the derelict areas, many of them becoming year by year more and more difficult to bring back into an economic state. Throughout the country there are many examples of what can be done; let all energy now be devoted to the study of what has in fact been achieved, to an analysis of the results, to the application of lessons learnt, and to research to fill gaps in our knowledge. The methods which will have to be adopted for speedier rehabilitation may at first seem unconventional, but if the work is with Nature and not against her and follows the Silvicultural Stream so ably described by Lord Robinson (1) in this Society's *Journal* eight years ago, neither attempting to stem the flow nor to ignore it, our present inadequate rate of progress can undoubtedly be much increased. Such work must be carefully planned from the start, and plans must be at the same time flexible and resolutely followed; there must be arrangements whereby all concerned are able to learn new procedures and are encouraged to apply them in their woods.

[*Received 10th October 1950*]

LITERATURE REFERENCES.

(1) Robinson, Sir Roy: 'Some Ecological Aspects of Afforestation and Forestry in Great Britain.' *Forestry*, xvi. 1, 1942.

(2) Wood, R. F.: 'Rehabilitation of Devastated and Derelict Woodlands.' *Quarterly Journal of Forestry*, xliv, No. 1, 5, January 1950.

A FALLACY IN THE THEORY OF GROWING STOCK

By R. BOURNE[1]

SUMMARY.

It is generally accepted that the theories of growing stock of von Mantel, Oettelt, and Pressler which in themselves are not strictly applicable to yield management of even-aged normal forest are equally applicable to uneven-aged selection forest and irregular forestry. Attention is drawn to the marked differences demonstrated in Switzerland between selection and uniform growing stocks. Figures for British beechwoods are given which also demonstrate this difference. It is fallacious therefore to apply methods of yield regulation for uniform forests to selection or irregular areas. There is a far greater volume of timber per acre in normal selection forest than in normal uniform forest. The physiological reasons are outlined and the evolution of irregular silviculture from unsatisfactory uniform methods on the Continent is discussed. Mixed woods of several species in harmony with local ecology are considered most suitable components of irregular stands, sharing air, light, and soil more efficiently and providing more suitable regeneration conditions. Figures from successive enumerations in Chiltern beechwoods are given to show development from uniform to irregular stocking, and the economic as well as volumetric advantages are demonstrated.

FORESTERS in general have been educated in the theory of growing stock, as formulated by Oettelt and Pressler, and as expounded (in English) by Schlich, who charged me, as lecturer in forest management, with the elucidation of the inconsistency expressed in the following quotation.

'Theoretically speaking, in a normal selection forest all age gradations should be represented in the same proportion as in the system of clear cutting in high forest; hence the volume should be the same in both cases. In practice, however, this is rarely if ever the case. As a general rule the older age classes occupy more area than the younger ones.' (Extract from Schlich's *Manual of Forestry*, vol. iii, 5th edition, 1925, pp. 219–20.)

The research involved exposed more than one fallacy in the theory of growing stock, explained in lectures and illustrated in the forest to students of the School of Forestry and Imperial Forestry Institute, Oxford, between 1928 and 1937.

Two of the fallacies had been brought to my notice in the course of the preparation of volume and yield tables for teak at Nilambur, India, in 1916–19 (3). Their effects have to do mainly with methods of yield regulation and do not materially affect the practice of forestry. The third fallacy, the one briefly reviewed in this article, not only involves very considerable modification and expansion of the theory of growing stock, but is already affecting practice in some countries, and in due course will affect practice in all countries.

The theory of growing stock is mainly concerned with forests of even-aged

[1] Mr. Bourne dictated the greater part of this article when very ill and weak, about a fortnight before his death on 30th November 1948. An old pupil and friend, Mr. M. J. Penistan, has completed the article from the notes and dictation left by Mr. Bourne, as closely as possible to what are believed to have been Mr. Bourne's wishes and ideas. See *Forestry*, vol. xxii, No. 2, 1948, p. 239, 3rd para. Mr. Bourne was awarded posthumously the medal of the Society of Foresters of Great Britain.

woods, a normal series of age gradations or age classes. With clear cutting, whether followed by natural regeneration or planting, a normal growing stock is dependent upon the presence in a forest of a normal series of age gradations, *by area*, each fully stocked. With natural regeneration over a comparatively short period, resulting in even-canopied woods, the normal growing stock is similarly dependent on the series of age classes by area.

It is desirable to emphasize at the outset that there are certain limitations in the stocking of forests by clear felling or natural regeneration over a comparatively short period. The main limitations are:

1 (*a*) The number of trees to the acre which can stand at rotation age on the annual or periodic coupe varies with the species, the rotation, the locality, and the method of thinning. The number of trees to the acre varies similarly at younger ages. Such figures are normally set out in yield tables.

(*b*) The trees in any age gradation or age class are also necessarily confined to a particular annual or periodical coupe, i.e. the 1-year-old age gradation must stand in Coupe 1, and so on, the oldest age gradation standing on the oldest coupe.

(*c*) The trees when cut at maturity, within a single crop, vary very greatly in size. Unless the thinnings have been of an extreme grade, it will often be found that the smallest trees in the crop are only half the size of the largest, involving problems in marketing.

2. The need to preserve the canopy throughout the rotation prevents the removal of many poor trees in the course of thinnings. It is rarer to go through even-canopied woods approaching maturity and see nothing but perfectly grown trees, such as qualify for special prices, than in uneven-aged woods. Indeed it will generally be seen in even-aged woods that quite a high proportion, if not a very large proportion, will only realize lower prices. I would emphasize here that this is not peculiar to any one country; the point is general wherever forests are man-made. More often than not, the exceptions are particular species, and particular sites, where natural regeneration is profuse, the trees have grown up in intense competition, and the good forester cleans and thins them with a view to the production of high-grade timber.

3. In all forests of even-aged woods there comes a time when it is something of a sacrifice to cut trees which are in a relatively immature state, i.e. in the older pole crops and in immature woodlands, merely for the sake of providing adequate growing-space for the final crop trees which remain. Even though few of these immature trees that are taken are of really high grade, they are at a stage when they are passing rapidly from the smaller sale classes to the larger or timber classes. In a manner they are growing into money but have to be cut for the sake of others. They often present very considerable difficulties in utilization and marketing.

The proper management of the growing stock and the harvesting of the

increment depend on keeping intact in the face of climatic and biotic influences every gradation in its appointed place. That this is exceedingly difficult to achieve is universally realized, and the subdivision of forests or working circles into felling series, and the splitting of the series into coupes, are efforts to disperse the vulnerable growing stock as much as possible, for the benefit of future forest managers.

When calamities occur, and they have affected all forests, a considerable loss in yield and dislocation of management results, as the forester is restricted more or less to the harvesting of a depleted crop on the damaged area when due for cutting, and must make considerable readjustment of his operations to repair the loss.

The moment a measure of irregularity, resulting in some unevenness in canopy, occurs in woodlands, from whatever cause, either as a result of some calamity such as a windfall or as a result of lengthening the regeneration period, a different set of conditions arises. It is this set of conditions which has to be described and its consequences expounded.

These conditions are very variable and almost universal in managed even-aged forests, whether the irregularity be due to storm or lightning, fire, frost, or the growing of unsuitable species and races, to emergency fellings in war-time, or to enemy action. They all result in dislocation of the growing stock as visualized by the forest manager and indicated by the figures given in yield tables. Depletion of the growing stock in the medium-age gradations may result in advance growth of more tolerant species and associated species, but as the area is allotted to a certain age class the new crop is ignored. These areas are considered failures and problem areas by woods managers, and the visitor is steered away from them.

When I returned from India in 1922 and started to lecture on forest management at Oxford I followed the traditional procedure of asking local foresters in the areas which I visited to arrange suitable excursions. It was soon apparent that they generally took me to see their successes, and rarely sought to demonstrate their failures, which undoubtedly existed. As the result of experience in India, more especially in the Nilambur teak plantations, I had come to realize the great necessity in forestry of distinguishing between the effects of local factors on the forests and the effects of the forest treatment. I had proved to myself the importance of soil surveys and, later, in the Himalayas, the significance of climatic surveys. In both areas, whenever one encountered forests or crops out of harmony with the local climate and soil, I immediately looked for the historical factor which had interrupted the natural development. In Great Britain and in general in Europe such interruptions in the natural development are general. Only here and there one encounters forests and crops with any close relation to the natural. By the time I had been round most of the areas visited by the School of Forestry, Oxford, I had separated the areas where the natural sequences are still to be traced, in spite of historical factors, from those areas where the forester had largely obscured the natural sequences by his plantations of exotics. I had also met the majority of those foresters who for one reason or another were departing in their practice from strictly even-canopied crops as a result of extensive failures with even-aged woods

management. These were: Mons. H. Biolley, Canton Neuchâtel, Switzerland; Oberforstmeister Stephanie, Baden; Forstmeister Arnold, Winterthur, Switzerland; Forstmeister Muhler, Biel, Canton Neuchâtel; and not least Dr. Hans Burger, Forest Research Station, Zurich.

At the outset none of them could persuade me, with my upbringing in even-aged forest management and my recent experience in the preparation of yield tables in India, that there could be any difference between the normal growing stocks of even-canopied and uneven-canopied woods, other than a redistribution of the age gradations or age classes over small areas. My firm belief was that when a mature tree was cut down, its place then had to be taken by young growth. I recognized that it might be advance growth, but only of a small size. I had *not* realized the great significance of sharing of space between large and smaller trees, poles and regeneration. Or, expressed in another way, I was not allowing for the effects of side light.

It is noticeable that wherever accidental opening of the canopy has taken place in even-aged woods, advance growth appears. This may be of the same species or of an associated species. The same occurrence is noticeable even under close canopy. Even where the opening is slight, the regenerated species may survive for a long time, and a large number of seedlings and a few saplings, through being able to utilize side light and other kinds of light than that of the overcrop, are actually occupying the same ground as another age gradation. By thinning the worst individual stems from the overcrop and allowing more light to filter and pass through the canopy, the undercrop can develop; and what was possibly a stand containing many rather poor stems may be considerably improved, with no loss in value, by improving the quality of the remaining crop, and at the same time recruitment is allowed to take place.

The recruitment stocking in irregular forest is subject to intensive cleanings. Only the finest stems are selected for growth into timber, and the 'selection' takes place in pole thinnings, not in mature woods. Because the recruitment stocking in uneven-aged forest develops in side-light shelter and reaches up into the open canopy, the branching is lighter and the resultant size of knots in the timber smaller than in even-aged plantations. This is particularly noticeable in the montane spruce–silver fir (*Picea-Abies*) forests, and in the Chiltern Hills of England, where first-rotation beechwoods (*Fagus*) are easily distinguishable from established forest.

As a result of advance growth a gradation area whose stocking has been depleted may carry crops which represent the whole stage of development from seedling to the age of the gradation. Further, all the varying size classes can be allowed to share space as they develop, and development of the younger recruitment size-classes can be encouraged at the expense of the older stems of poor form.

On account of these facts and the constant interference of natural elements in the management of even-aged forests, the foresters already mentioned accepted and tended advance growth and adapted their management to local circumstances. Where an uneven-aged series of sizes and ages does suffer windblow, the dislocation is local and does not affect the normality to the same extent as would a windblow

in an even-aged gradation area. Further, the windblow will be reduced owing to the broken canopy, and forest conditions will not be destroyed, while the necessary recruitment will be there already on the ground.

From the inception of advance growth in even-aged stands, whether it be in the beech, silver fir, and spruce forests of Switzerland, the pine forests of Prussia, the beech and mixed woods of southern England, it has been found that the undercrop will grow whilst sharing the light with the overcrop, resulting in a storied forest; and where this has been appreciated, further thinning and improvement has meant that increment is not only concentrated on the finest stems and maintained but that a new crop becomes established below. While the volume increment of the overcrop may be reduced, the value increment will probably be increased.

The appreciation of these phenomena and the modification of forest practice to take advantage of them has long been accepted in Switzerland, and the development of the technique is described generally by Knüchel (8, 9). Research has been undertaken on the use of different wave-lengths of light by species and races, and on the physiology of uneven-aged woods, by Knüchel (10) and Burger (4). Photosynthetic activity may be towards one or other end of the spectrum, according to species or even race. This explains the often observed but little acted upon appearance of oak seedlings under pine or vice versa; ash (*Fraxinus*) under beech; spruce under silver fir; light-demanders under shade-bearers; the mixture prospers if fostered.

In even-canopied woodland where there is no understorey the wind sweeps through, drying up atmospheric humidity. The crowns of the trees give off water vapour and carbon dioxide into the atmosphere, where it is lost to the tree. In uneven-canopied woodland, with regeneration below, and poles, beneath the upper canopy there is no windswept effect, the air is stiller, and a lot of water vapour and carbon dioxide given off by the lower stories is able to move up through the crowns of the bigger trees before it is swept away. The bigger trees keep their thickest branches down to one-half or one-third of their height but have 60–70 per cent. of their total contents in the clean cylindrical lower bole (5).

The technique of fostering advance growth and allowing it to develop, to make uneven-aged and uneven canopies, has enabled foresters to ignore the need to maintain a series of areas of age gradations. Recruitment takes place all over the forest, and instead of control being by age and area, it is by volume, the largest trees only being cut to harvest the increment and maintain the growing stock. Not only are the areas occupied by each age class mixed over the whole forest, but owing to the use that can be made of side light, and mixtures in which the tree roots share varying levels of the soil, the spaces occupied by each age class are telescoped and shared.

The saving of space and sharing of light and forest atmosphere, in irregular stocking, mean better use of soil space than in even-aged pure woods or even-aged mixed woods. Owing to the concentration of increment on the larger trees, which have good long crowns, stands are windfirm. Indeed the great dislocation of

growing stock by storm damage in even-aged woods has greatly influenced the Swiss in their adoption of uneven-aged woods.

Provided there are sufficient of the younger classes, age no longer really matters; it is size that matters; and in extraction of the timber, provided good axemen are employed, there is really less damage caused in abundant regeneration than in the uniform strip system. With the uniform strip system a large number of the final crop trees have to come down in one felling, over a small area of quite dense regeneration, whereas in the uneven-canopied woodland it is only a large tree here or there that is felled at any one time. It is worth mentioning that in parts of Württemberg, in particular, natural regeneration of spruce, &c., under Wagner's *blendersaumschlag*, was abandoned for the clear felling strip system with planting, simply because of the damage to regeneration caused by the inevitably concentrated felling over the new crop.

Having briefly noted the conditions obtaining in uneven-aged selection type stands we can pass to the consideration of the growing stock in such forests. From what we have shown above, it follows that the growing stock in uneven-aged woods does not conform to a series of age gradations as assumed by Schlich, owing to the sharing of space between the larger and the smaller size classes. In selection forests the growing stock is assessed by size and number of stems, not by the age area occupied by each age irrespective of size. It is not possible, therefore, to use the accepted growing-stock concepts of Oettelt, von Mantel, and their modifications, in the management of selection or uneven-aged woods.

On account of the inherent disadvantages of uniform even-aged management methods and the dislocation of these methods by unforeseen natural or unnatural causes, the Swiss foresters adopted uneven-aged forests and evolved methods of management by successive enumeration. They found that after their heavy thinnings to allow the regeneration to develop, the increment did not decrease but often increased, and this increase was now concentrated on the very best stems. Figures of the growing stock which were being produced both as a result of enumerations and conversions from uniform woods, as at Couvet under Biolley (2, 6, 8), at Forbach by Stephanie, or by Balsinger (1) in the Emmenthal, where selection was traditional, did not compare with those produced by the calculations made for Swiss yield tables by Flury of Zurich (7).

Flury was one of the first to point out that uneven-aged and even-aged woods could not be compared until the sample plot data were reclassified according to size-class distribution and not age. When he published his yield tables for Swiss woods in 1914, he emphasized that *a far greater volume* of the larger size classes was found in selection woods. In 1929 he gave further comparisons for five quality classes.

Selection forests do not carry all age gradations in the same proportion as even-aged high forest or a series of age gradations. The fact that space is shared means that more large trees can be carried on normal irregular forest, with ample regeneration and recruitment. Also as a result of the freeing of advance growth by removal of the poorest older stems, which older stems must be retained in even-aged crops to maintain forest conditions, this greater volume of large timber in

irregular forest is concentrated on the finest individual stems, so that in addition to the volume of large timber being greater, the value of this timber in any revenue coupe is considerably greater.

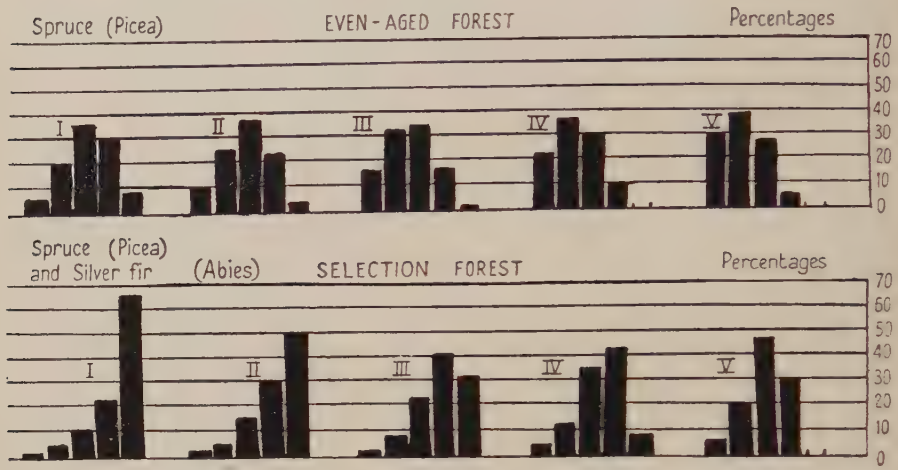


FIG. 1. Percentage distribution of the ideal total growing stock by size classes for five quality classes in Swiss montane region.

Five size classes by diameters in centimetres for each quality class, reading left to right, 8 to 14, 16 to 24, 26 to 36, 38 to 50, and 50+.

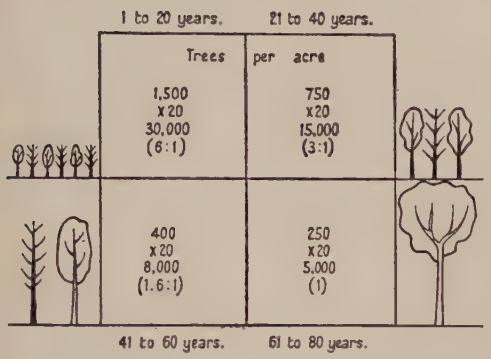
A great range of sample plot data for selection woods in Switzerland exists. The figures for the communal forest of Couvet, Canton Neuenburg, where Biolley (2, 6) worked out the details of his *Méthode du Controle*, can be referred to in Knüchel's *Management Control in Selection Forest* (8).

Biolley's figures illustrate graphically the conversion of even-aged to selection stocking, with the subsequent increase in volume of the largest sizes of stems, accompanied incidentally by the evolution of a workable method of management.

The data and diagram of Fig. 2 illustrate this saving in simple terms. The notes should be read first. The data are taken from within the range of available figures, rounded off to permit of mental arithmetic. The first diagram represents four age gradations in even-aged woods. The three entries in each square are: first, stems per acre, then stems in age gradations (20 age-classes in each); with the ratio of current stems to final stocking, for example, 250 is to 400 as 1 is to 1·6. The volumes of these stems are computed from trees of assumed mean volumes of $\frac{2}{3}$, 2, $7\frac{1}{2}$, and 18 cu. ft., respectively, to give the growing stock, and the yield from thinnings and final yield are set out, with the money yield. The thinning yield which arises before the 20th year is arbitrarily placed at 300 cu. ft., and the volumes of the mean thinnings are assumed to be $1\frac{1}{3}$, 4, and 12 cu. ft. for the three successive intermediate periods.

In the second diagram it is no longer possible to show any definite area occupied by an age or size class. The classes are intimately mixed. The number

FORESTS OF EVEN-CANOPIED CROPS (80 ACRES)



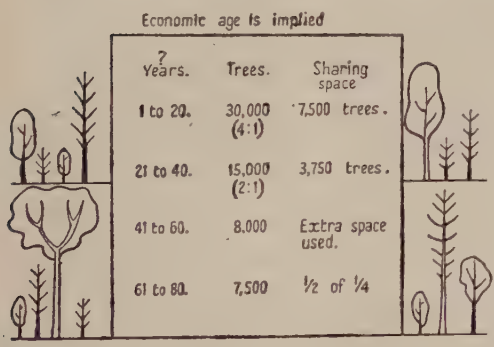
Stock *No.*	*Av.*	*C.ft.*	Yield (annual) *No.*	*Av.*	*C.ft.*
..	..	..	..	..	300?
30,000 × ⅔ =		20,000	15,000 × 1⅓ / 20		= 1,000
15,000 × 2 =		30,000			
			7,000 × 4 / 20		= 1,400
8,000 × 7½ =		60,000			
			3,000 × 12 / 20		= 1,800
5,000 × 18 =		90,000			4,500
			90,000 / 20		= 4,500
		200,000			9,000

Money yield. Intermediate at 8*d.* per c.ft. on 4,500 = 3,000*s.* Final at 1*s.* 4*d.* per c.ft. on 4,500 = 6,000*s.* Total yield 9,000*s.*

Notes

1. Production is limited by the number of trees of any age which can stand to the acre, and by the fact that they must stand in defined areas.
2. The need to preserve the canopy throughout the rotation prevents the removal of many poor trees.
3. A big sacrifice is involved in having to thin so many immature trees just prior to maturity.
4. With trees of the same age, the smallest trees in a crop are roughly half the size of the largest, so that many trees are cut on the small side.
5. With planting in wide espacement (4½ ft. +), it is impossible to produce clean timber without pruning.
6. Brashing is often a very expensive operation.

FORESTS OF UNEVEN-CANOPIED CROPS (80 ACRES)



Stock *No.*	*Av.*	*C.ft.*	Yield (annual) *No.*	*Av.*	*C.ft.*
..	..	..	..	..	600?
30,000 × ⅓ =		10,000	15,000 × 2 / 20		= 1,500
15,000 × 1⅓ =		20,000			
			7,000 × 6 / 20		= 2,100
8,000 × 7½ =		60,000			
			500 × 12 / 20		= 300
7,500 × 24 =		180,000			4,500
			180,000 / 20		= 9,000
		270,000			13,500

Money yield. Intermediate at 8*d.* per c.ft. on 4,500 = 3,000*s.* Final at 1*s.* 8*d.* per c.ft. on 9,000 = 15,000*s.* Total yield 18,000*s.*

Notes

1. Production is greatly influenced by the fact that trees of different sizes can share space in the canopy, and by the fact that trees of different ages are not bound to stand in defined areas.
2. The possibility of breaking the canopy permits the removal of all poor trees at an early age.
3. All good trees grown through to the large pole stage can be kept to mature.
4. Each tree can be grown to its most economic size.
5. With planting with wide espacement, in partial shade, trees can be drawn up and will prune themselves.
6. If the woodmen thoroughly understand the principle of cleaning, or early high thinning, they can make the forest, greatly simplifying the work of the forester in the later thinnings.

FIG. 2

of stems in the smaller classes is the same as in the even-canopied diagram, but as these are developing in side shade, they are sharing space with the larger classes and more large stems can be grown on the same area than in even-canopied woods. The ratios in brackets show the number of stems from which one final crop tree will be developed. The stem volume of the two smaller size-classes is less than in the even-aged; it is in the second stage that the selection thinnings take place to free more advance growth and seedlings below, leaving only the finest stems. These fetch a better price when the annual coupe is made.

A further graphical expression of space-saving through the use of side light and mixture is shown in Fig. 3. Four size classes are shown, which we shall call seedlings, saplings, poles, and timber trees. The table gives the number of stems in each case.

Case	*Seedlings*	*Saplings*	*Poles*	*Timber trees*
1. Even-aged	640	298	138	64
2. Group irregular	608	224	128	96
3. Selection	600	269	140	113

The sections show the type of crop for each stocking.

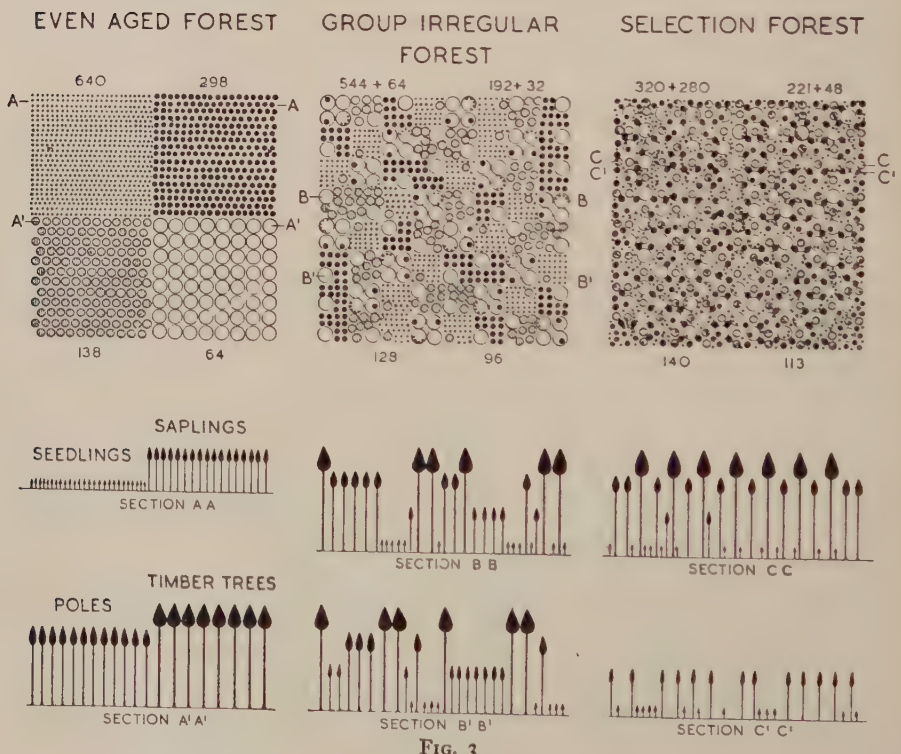


Fig. 3

Finally, by way of comparison with Biolley's and Favre's figures of progressive enumerations in Swiss Jura selection forests, the figures for certain Chiltern beechwoods show the progressive development of size-class distribution under selection management (Fig. 4). The figures are from Parmoor beechwoods[1] and refer to three compartments. In addition to the improvement in size-class distribution and in the proportion of the larger size-classes, ample recruitment has been established naturally, backed by limited planting.

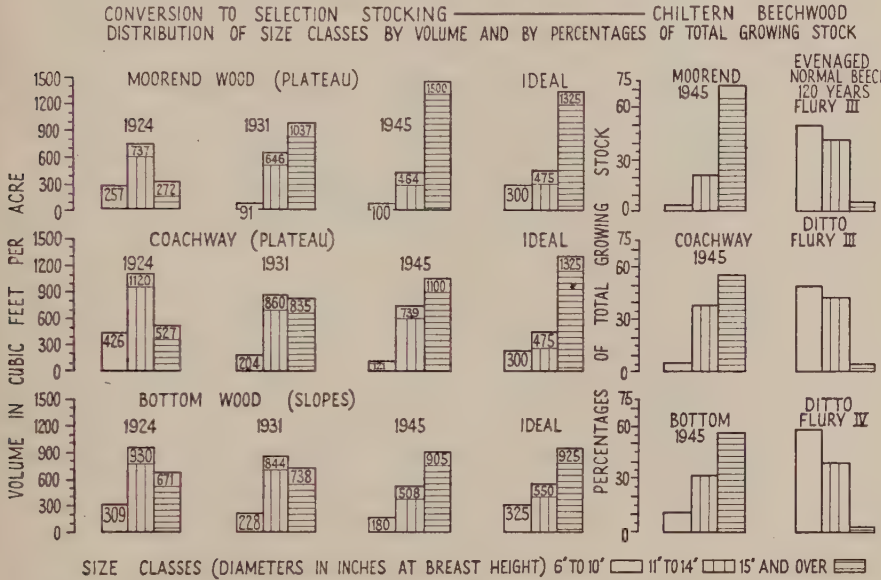


Fig. 4

At the inception of management under the Method of Control, Moorend and Coachway were even-aged woods in the later middle stages of development. They are on Chiltern plateau sites, on clay-loam soils of the Hampden and Christmas Common series. These sites do not produce the best quality beech but might be said to be average and to produce a mature height of dominant trees of 80–90 feet. The third example, Bottom Wood, occupies the sides of one of the typical dry valley-heads of the Chilterns; the soil is shallow over the slopes, but in the bottom there is a small area, deep, well drained, and of high fertility. On the whole, though, this site is of lower quality than the other two, producing a mature height of dominant trees of 70–80 feet. In 1924 this wood was much more even-aged.

Regeneration has been successful, ash being accepted and encouraged. There has been some local planting of oak in bramble (*Rubus*) areas at wide spacing, to back up ash regeneration and to introduce mixtures of species. The development of size-class distribution towards selection stocking is shown by enumeration

[1] As far as is known, the Parmoor beechwoods are the only example of the method of control in England, at present. [Editor, 1950.] The figures themselves are to be published in Volume xxiv, No. 2.

statements and graphically. The size classes correspond approximately to those of Flury, though his small class has not been enumerated in the Chilterns.

The ideal growing-stock distribution is that worked out for the Chiltern beechwoods during forest management field-work by Oxford forestry students. The total growing stock for uniform regeneration on 120 years' rotation (which age corresponded with that of the mature dominants) was calculated graphically from Schwappach's yield table for beech, Quality III, and used to indicate what might be expected per acre from total uneven-aged stocking. The volume size-class distribution was made from stem-diameter curves and local tariff volume tables.

The total ideal growing stock in the plateau woods was calculated to be 2,100 cu. ft. per acre, and on the slopes 1,800 cu. ft. per acre. The distribution is shown in the fourth set of columns in each case.

In addition to the ideal size-class distribution by cubic feet, the 1945 stocking is shown as percentages of total growing stock and compared with Flury's figures for beech of similar total stocking.

The immense differences in the distribution of size-classes in selection and even-aged beech is most striking, and while this difference may be modified when comparison with yield tables for British beech is possible, it is a safe assumption, from the comparisons in other countries for comparable growths of beech, that there is a much greater proportion of large timber in uneven-aged selection woods.

The development of size-class distribution is also drawn graphically on the same form used by Biolley and Favre, the size classes corresponding in each case with those used by Flury (Fig. 5).

CONCLUSIONS.

1. It has been demonstrated abroad and in the Chiltern Hills of England that a selection-type growing stock in a given forest carries more large size timber per acre than an even-aged growing stock. It is fallacious to apply to selection forests growing-stock figures calculated from yield tables computed from even-aged stands.

2. This more efficient selection type of stocking has developed from modified practice adopted owing to failures in the management of forests according to even-aged yield-table methods.

3. The selection-type forest is less vulnerable to calamities such as storm than even-aged forest.

4. To ensure still higher stocking, some degree of mixture is preferable, as better sharing of space, light, and soil results, and regeneration is helped.

5. The larger quantity of timber produced per acre in selection forest is also of higher quality because regeneration crown thinnings remove the poorer stems. Thus in addition to the mere superiority in quantity of large timber, the value of selection forests tends to outstrip the value of even-aged woods.

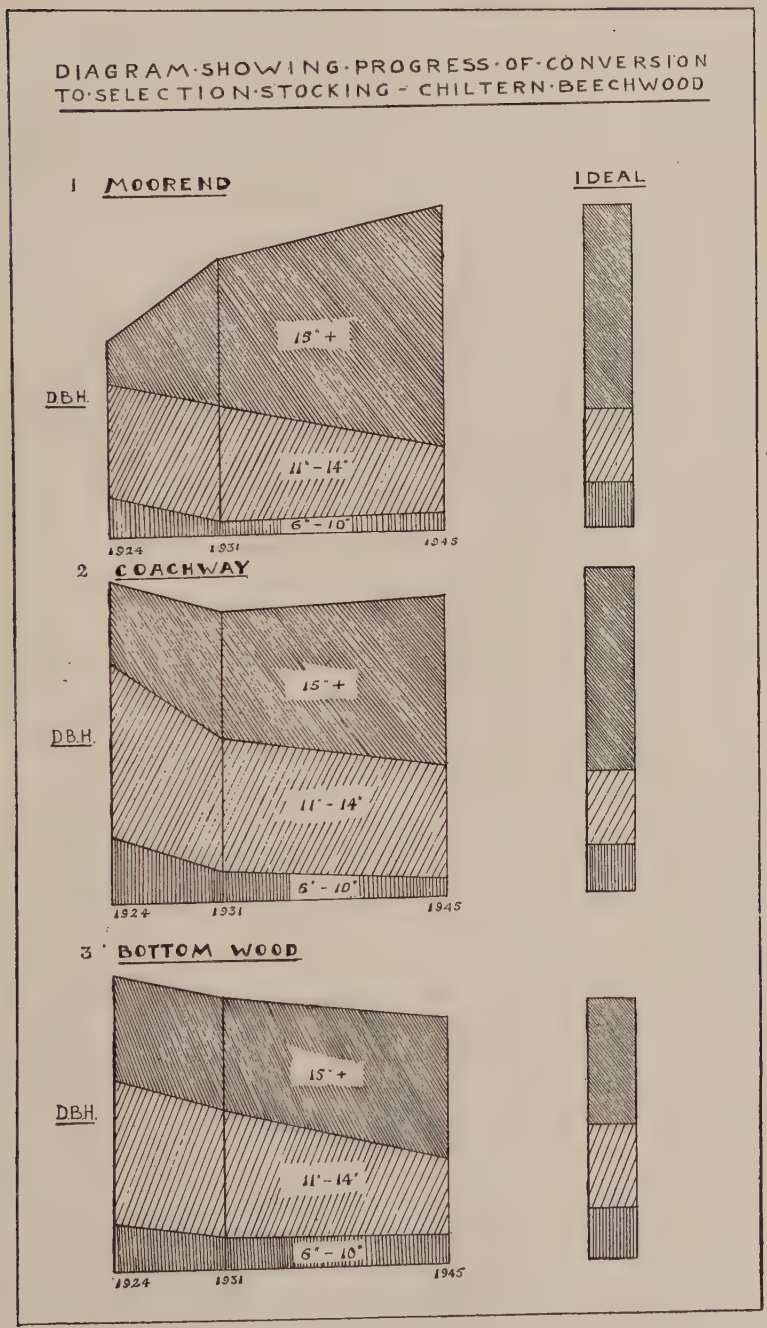

DIAGRAM·SHOWING·PROGRESS·OF·CONVERSION
TO·SELECTION·STOCKING - CHILTERN·BEECHWOOD
1 MOOREND
IDEAL
DBH.
15"+
11"-14"
6"-10"
1924
1931
1945
2 COACHWAY
DBH.
15"+
11"-14"
6"-10"
1924
1931
1945
3 BOTTOM WOOD
DBH.
15"+
11"-14"
6"-10"
1924
1931
1945

FIG. 5

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THE POSSIBILITIES OF IMPROVING FOREST TREES

By C. SYRACH LARSEN

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SUMMARY.

A plea is made for attacking the problem on original lines. After stating the more important methods of approach, the article, which is illustrated by two photographs, explains briefly how the use of grafts can overcome the inherent difficulties of space and of time in undertaking artificial pollination. The establishment of plantations of trees propagated vegetatively and therefore of known genetic character has in Denmark afforded a means of preserving the presumed valuable genotypes and also helped in the difficult problem of their identification and opened up wide opportunities for further research. On a larger scale such plantations, formed from *élite* trees, provide seed for practical purposes. The article follows the lines of the address given by the author to the British Association at Birmingham in 1950, and ends with some words of encouragement to research workers in Great Britain.

IT may seem remarkable, although reasons can be brought forward to explain the fact, that the silviculturist should lag far behind the farmer or the gardener in the use of improved plants. Should we have in mind the propagation of 'fixed strains' on the basis of artificial pollination, then we shall have difficulty in carrying out pollinations high up in the crowns of tall trees (Fig. 1). Further, we shall perhaps find that the best trees are scattered over wide distances, and we cannot transfer these to a convenient experimental area. Improvement has till now, broadly speaking, only consisted in the introduction of exotic tree-species and selection on the basis of free, uncontrolled pollination. We have seen with envy the great advance made in the use of improvement technique by the other soil users. Unfortunately the emphasis placed on the special difficulties of its use in forestry has impeded progress. The difficulties are great if we try to follow the same procedure which has been employed in agriculture and horticulture, but if we go our own way, then perhaps things will assume a different aspect. The most important methods of procedure in improvement work in forestry are:

Investigations to *establish hereditary differences within species*.

Artificial pollination on a foundation of previous studies of the flowering of forest trees.

The use of *Hybrids*, especially the utilization of hybrid vigour.

Cytological work to identify trees having chromosome numbers differing from the normal as well as the reproduction of such trees.

The use of *vegetative propagation* as a technical method of the greatest importance for the establishment of 'seed-source-plantations' and 'tree-displays'.

First and foremost, we should aim at preserving for the future the best possible types and any specially outstanding individuals, *élite*—or champion—trees. This is *the preservation of presumed valuable genotypes*, which will become available for further use and in any case offer a certain safeguard against deterioration. In this, *space* is an important problem. Often the trees, which one wants to handle, are

scattered over a wide area, so that it would seem impracticable to make use of them. To have our selected champions collected together in our arboreta is to have achieved much. *Time* acts as a deterrent perhaps even to a greater degree than does space. Grafts are, however, capable of furnishing seed at early ages, even when they are planted out in the forest in the same manner as other trees (Fig. 2). It has been clearly proved that grafts, treated by special methods, grown in pots or subjected in some other way to special treatment, can be used as small, early-fruiting plants for experimental purposes. It is a very great advantage in a greenhouse to be able to work with such seed-bearing pot-plants. When, in addition, one can be certain that they are grafts with exactly the same genetic characters as the *élites*, from which they are taken, then one can be unreservedly grateful for the opportunites which this offers for future research.

Identification of the genotype in forest trees is also a hard problem. Forest trees are dwellers in communities where, like other living organisms, they have to adapt themselves to existing conditions, which may differ considerably: the more so since trees live so long and may have been subjected to external influences, which we in our lifetime have had no opportunity to control. As an aid in identifying the genotype in Denmark we have initiated 'tree displays'. These are plantations of groups of various sizes of plants propagated vegetatively, so that each group represents its own particular tree—its clone. In the arboretum at Hørsholm we have in this way derived much assistance in identifying the genotype in respect of clones of *Fagus*, *Fraxinus*, *Betula*, *Larix*, *Picea*, and *Pseudotsuga*. While, in the first place, 'tree displays' seem to me to be a means of demonstrating the existence of various genotypes, they also present a favourable opportunity for continuing our observations and trials on into the future. Moreover, they can be planned in such a way that it also becomes possible to test individual genotypes under different environmental conditions. How valuable they may be as laboratories for both plant-physiological and plant-pathological studies, or simply for phenological observations. There we shall become alive to the great individual differences which form the basis of improvement. One becomes surprised not only at the amount of knowledge which can be derived from it but also how rapid is its progress.

It is so often said in plant improvement work that we must follow the plant from 'the cradle to the grave' in order to be sure that we have found the right and really valuable plant, but I believe that in forestry we should follow the individual tree from 'the grave to the cradle'. For is that not just what we are doing in our use of 'tree displays'? The shapely, full-grown tree in the forest stands on the brink of the grave, but it has made clear to us that it could become for us the ideal tree. When we take grafts from it and establish these in our tree display, we then have an opportunity to study the congenital characters which have made it possible for it to become such a valuable tree. In the course of a few years we shall be able to see whether it was exceptional vigour which was the reason for its superiority, or whether it was great hardiness or a special capacity for resistance to diseases, which gave it a lead over other individuals. Thus it seems to me that we can say 'that we have followed it from the grave to the cradle', even if it sounds perhaps

FIG. 1. Larix. Controlled pollination of larch in the forest. A 29 meter scaffolding for breeding experiments. Tinghus plantation, Denmark, 1935

FIG. 2. Larix. Controlled pollination of larch in the arboretum. Grafts from the tree in Fig. 1. Grafted 1935 and 1936. Hørsholm, Denmark, 1950

PLATE I

somewhat bizarre. It is, however, a striking example to illustrate the need to follow paths other than the normal ones.

With regard to *seed-production*, I say as I said in 1934: 'I strongly urge, therefore, taking up vegetative propagation and, in conjunction with experiments in artificial pollination, establishing seed plantations for the supply of seeds for practical use.' In Denmark the work has been so organized that most of the experimental work on forest tree improvement is concentrated at the State Arboretum, whereas the establishment and control of seed-source gardens is the main task of the State Forests' Plant-breeding Station. Above all, seed-source gardens, which are formed by means of vegetative propagation from *élite* trees, will be our trump-card against agriculture and horticulture. We should not cast envious eyes on the favoured position of plant improvers who work with herbaceous plants, but rather look at the matter the other way round. *Therefore do not let us lament the slow succession of generations, but rather rejoice at the long life of the individual.* In this connexion I would like to direct attention to the 'polycross method', used with success in recent years in agricultural plant improvement. The method is specially recommended for plants which are cross-pollinators, which can be divided into clones and can thus be preserved for a number of years. Such is the case with our forest-trees.

Whatever may seem to be the best, we must, working with the greatest precision, try to get to grips with the heart of the problem in order later to make use of the discoveries in practice. In order to achieve this it is up to each of us to tackle the problems as we see them, but at the same time we must also try to *co-operate* in the best possible way. It is pioneering work.

If we are successful in this to any appreciable extent, then we shall be approaching the stage where it will become obvious how much more profitable it will be to create rapid-growing pure plantations on favourably situated areas, instead of going on the hunt for countless different species in virgin forests, or waiting on the regeneration of the forests of the far north. Those regions of the world, including Great Britain, which are favoured by abundant amounts of light, heat, and moisture hold out high possibilities. Remember, if you want to take up this task, it is not real work: it is good sport!

[*Received 20th September 1950*]

A STUDY OF GROWTH RINGS IN TREES

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Part I. *Review and Discussion of Recent Work*

SUMMARY.

Some key references from the considerable literature on the subject are cited and some discussed in full as a background to this paper which is mainly concerned with work done since Glock's review of 1941, and with work in Great Britain not hitherto reviewed. It is pointed out that systematic study has been largely undertaken by archaeologists and climatologists with definite ends in view rather than by foresters, and that the pioneer work of Douglass on the yellow pine in the dry climate of North Arizona which established a high degree of correlation between ring-width and rainfall has resulted in spite of warnings in focusing undue attention on this. The work of Lowther, Salisbury and Jane, and of E. W. Jones in Great Britain and of Weakly and of Will in the United States of America is also discussed. It is considered that outside the region where rainfall can be shown to be the limiting factor in tree growth, the use of the single quantitative character of width is unreliable. In the study of growth rings in European larch which follows as Part II in a future issue of this *Journal*, it has been found possible to identify and date the annual growth layers by means of their qualitative characters and to simplify the growth pattern for presentation in terms of the frequency of multiple-growth layers within the annual increment.

INTRODUCTION

THE growth rings of trees have been studied from several different points of view, by archaeologists, by climatologists, and by foresters and botanists, but it may be fairly said that those whose concern is primarily with the trees themselves have shown the least interest in the remarkable record which the tree leaves behind it in its wood.

This is understandable, because it is they who are most likely to realize the complexity of that record and the difficulties in the way of its correct interpretation; but as a result, although references to growth rings are innumerable throughout the literature of forestry and dendrology, they are for the most part isolated. A useful summary of the older observations may be found, for example, in chapter vi of Büsgen, Münch, and Thomson's text-book (5), but for any considerable body of systematic study of the subject we have to look to those who have been concerned chiefly to use the tree as a tool, either for the dating of ruins, &c., or as an indicator of climatic conditions in the past.

Some knowledge of tree rings goes back at least four centuries to Leonardo da Vinci, who made a characteristically fundamental contribution in all three of the fields mentioned above, by pointing out that the age of a tree may be determined by counting its rings, that water has great importance for tree growth, and that the thickness of the rings reveals the nature of the seasons, whether wet or dry (*vide* W. S. Glock's review (16)); but for practical purposes modern tree-ring studies may be said to have started with the climatological researches of A. E. Douglass (6).

As these in turn led on to the use of cross-dated tree rings in determining the age of Pueblo Indian and other ruins in the south-western United States, and since few archaeologists, at least in America, have failed to draw inferences about climate from their archaeological tree-ring material, the two fields of work have been from the start, and remain, very closely related.

As there is now a voluminous literature on the subject, it may be useful to record here a few 'key' references for the benefit of those who are not familiar with that literature. A fairly recent and lucid introductory summary, from the climatological point of view, is that of Harwood (18). The most comprehensive and critical review (with 222 references) is that mentioned above, by Glock (16). Zeuner (32) gives a useful introduction to 'Dendrochronology', as the business of estimating dates by analysis of tree rings has now come to be called. Methods are dealt with by Glock (13), and Douglass (8) gives an entertaining account of the first, and sensationally successful, application of his methods in the archaeological field. The Carnegie Institution publications of Douglass (6, 7, 9) on climatic cycles and tree growth, of Huntington (20), and of Antevs (1, 2) should also be included in any list of key references.

It is unnecessary here to repeat the substance of any of the above publications, but it is essential to emphasize certain points contained in them, for the purposes of this review, which is concerned chiefly with papers published since Glock's review of 1941, and with work on the subject in Great Britain which has not hitherto been reviewed. The whole course of the development of tree-ring studies has been influenced by the circumstances in which the pioneer studies of Douglass were made; that is, on the yellow pine (*Pinus ponderosa* Dougl.) in the dry climate of northern Arizona. The yellow pine has proved to be one of the most suitable and sensitive of trees in the variation of its ring-widths, and under the limiting conditions of moisture prevailing on the dry Arizona plateau Douglass was able to establish a high degree of correlation between ring-widths and rainfall, provided a suitable 'precipitation year' was chosen, to include early winter snowfall in the following year, and to take account of the moisture-storage capacity of the soil. He also produced an empirical formula for calculating mean rainfall from mean tree growth on the Arizona plateau. This included corrections for reduction of ring-width with increasing age of the tree, and the effect of conservation of soil moisture, and gave, he claimed, an average accuracy of 82 per cent. for individual years.

The spectacular success of this work seems to have focused an undue proportion of attention not only on the one climatic factor of rainfall but also on the one quantitative character of the ring, its width, and on the correlation between the two. And although Douglass himself was the first to issue a warning that his results were not of universal application, that has not prevented the appearance of a great many 'dendrochronological' papers in which the assumption is made that because some correlation may be found between ring-widths and the rainfall records of a modern meteorological station over a few decades, such correlation can be projected backwards into the past indefinitely, and even that, as Leonardo said, the thickness of the ring reveals the nature of the seasons, wet or

dry, so that over a long period, thin rings may be labelled 'dry years', thick rings 'wet years'.

GLOCK'S CRITICISMS: SMOOTHING.

W. S. Glock, in his review (16) mentioned above, has dealt rather severely with work based on this type of assumption, pointing out, among other things, that the usual Pearsonian correlation coefficient, designed for the sampling of populations, is of very doubtful applicability to continuous time series such as these, and that in some cases, where sufficient data have been given to provide the comparison, a high correlation coefficient does not necessarily mean a high correspondence of the crests and troughs in the graphs of rainfall and ring-widths, respectively. Hawley (19), for instance, gives $r = 10{\cdot}6949$ for tree-growth correlation with the rainfall of the water year (October–September). 'If her graphs are compared, they show 14 years of parallel trend and 8 of opposite.' Other such comparisons have given even less conclusive results, although, usually, sufficient data are not published to provide such a check.

The practice of 'smoothing' graphs by averaging the widths over a period is commonly adopted, on the theory that the variations which are thus eliminated are local and individual and of short-term effect, so that the 'smoothed' curve represents more closely the general climatic pattern, which may thus be used for cross-dating where required. The Hahn formula, whereby the middle of three successive numbers is given double weight [i.e. the value $\frac{1}{4}(a+2b+c)$ is substituted for b], is probably the most used. Antevs (2) 'smoothed' all his tree-growth curves twice in this way.

'DENDROCHRONOLOGY' IN GREAT BRITAIN.

A. W. G. Lowther (23), who appears to be the pioneer in the use of tree rings for archaeological dating in Great Britain, follows the Antevs method. By matching the 'smoothed' graphs of ring-widths from excavated oak timber (much of it waterlogged) and other archaeological material, including medieval oak chests in Westminster Abbey, he has succeeded in establishing enough 'overlaps' to build up two 'chronologies'; one pre-Roman and Roman, about 160 B.C. to A.D. 250, dated by means of pottery, &c., to within some 20 years only, the other Saxon and medieval, about A.D. 850 to 1500, which can be dated by historical records to within a year or two.

As Glock points out, by successive 'smoothing' a graph approaches nearer to a straight line, so that the correlation between 'smoothed' graphs is naturally increased. The more one 'smooths', the easier it is to find simple patterns of humps and hollows in the curves which will correspond, and the evidence of cross-dating presented by the matching of selected portions of such curves is extremely inconclusive to one who has not seen the timber or even the original graphs. Nevertheless, it does not at all follow that the sequences established by such studies are false, or that the dating is incorrect. It is very probable that in the course of the laborious examination of the rings necessary for such work the subtle pattern of the wood itself, rather than of the graphs made from it, has

impressed itself on the mind of the worker; and it is this which may provide a valid, if sometimes unconscious, basis for cross-identification. Moreover, in this sort of work certainty increases with the number of specimens examined, and when the same sequence, even in the graph, has turned up a dozen or more times, it begins to be recognized with an assurance which at first was entirely lacking.

It is of interest, also, that Lowther is working on a hardwood, whereas the great bulk of tree-ring work has been done on softwoods. The waterlogged timbers in particular, he writes, present difficulties, as they have to be studied in the wet condition, otherwise the outside collapses and the rest splits and becomes useless. Such timbers cannot be satisfactorily planed or otherwise smoothed up for examination; nor, presumably, can valuable material such as the Abbey chests; but fortunately some of these ancient timbers make up in size for what they may lack in detail, giving ring sequences up to 300 years in length. These, plotted on a horizontal scale of 10 rings to the inch, give plots several feet in length, which clearly cannot be published but may well provide a satisfactory basis for approximate cross-identification. The method is doubtless that best adapted to the limitations of the material.

Finally, with regard to Lowther's work, it may be noted that it is at present restricted to oak timbers from the drier south-eastern counties of England, that he rejects sections with irregular rings, which he attributes to growth on boggy sites, and draws no conclusions about climate from his work, which is aimed strictly at the dating of his materials. From the forestry point of view it is of interest to have it demonstrated that at least approximate cross-identification can be established between the rings of large oak timbers in this country.

RECENT WORK IN THE U.S.A.

Meanwhile, in the U.S.A., since Glock's review of 1941 (16), 'dendrochronological' papers have continued to be published, based upon the orthodox Douglass and Glock methods, using a 'skeleton plot' of the position of relatively narrow or broad rings. The work of Weakly (30) in western Nebraska provides a typical example.

Weakly worked chiefly on red cedar (? *Juniperus scopulorum*), with a few specimens of ponderosa pine (*Pinus ponderosa* Dougl.). As usual in this type of work, suitable trees had to be very carefully selected. 'Probably not more than one tree in five or six in this section of the country produces a trunk of sufficient symmetry to be usable.' Furthermore, those which have a good water-supply or are in very exposed or difficult positions are of little or no value. Hardwoods were rejected largely on account of their frequent production of false rings, due to late frosts, insects, or drought. Chiefly used were trees from moderately exposed positions on hill-sides, which might be expected to be the most sensitive to moisture fluctuations; but as logs were also used from old buildings, and stumps buried in the bottoms of canyons and gullies, there could be no certainty that the material used was all of one type. Some of these old buried trees pushed the

chronology back to 1480, but, as is usual, such lengthy chronologies depended entirely upon a few specimens.

Correlation of ring-widths with local weather bureau rainfall records varied from $0{\cdot}68 \pm 0{\cdot}07$ to $0{\cdot}51 \pm 0{\cdot}07$ but was higher, up to $0{\cdot}76 \pm 0{\cdot}05$, when the cross-sectional area of the rings was used instead of their width. The duration of these records was at one station as much as 64 years; and on this basis a chart which is published, showing years of subnormal increment from 1540 to 1940, is described as a chronological record of dry years. Similarly a table is published giving droughts of 5 years or more, and periods between droughts, over the same 400 years; and as groups of narrow rings recur at irregular intervals, the conclusion is drawn that that part of the country has been subject to protracted droughts over the whole of this period, and 'Hence the deterioration of native grass cover and the dust storms of the past few years do not indicate a permanent change of climate of this section, but more probably a recurrence of conditions that have prevailed before.'

A more recent paper by Will (31) from North Dakota follows very similar lines but goes even farther in identifying ring-widths with rainfall. After referring to the work of Douglass, Hawley, and Weakly, the author, on the first page, makes the following statement: 'The method of obtaining precipitation records from tree rings is based on the fact that annual rings in all trees vary in width depending on the amount of moisture available to the roots in the year in which the ring is formed. This fact was definitely established many years ago by Dr. Douglass. It is hardly necessary to present further proof.'

Later in the paper a comparison of the U.S. Dept. of Agriculture Weather Bureau's precipitation records for the whole State with the tree-ring record for a local area shows 41 out of 54 years in agreement; and on this basis a chronology from 1406 to 1940 is expressed in a table, not only of dry years, but of wet years, or periods; and the conclusions of Weakly for western Nebraska, quoted above, are found to apply to the less arid region of North Dakota, with further inferences as to the type of irrigation which might be practicable in such a 'marginal' climate subject to an irregular alternation of wet and dry periods.

Will's paper is of additional interest because his material was mainly burr oak (*Quercus macrocarpa* Michx.), and he appears to have overcome, by the use of an enlarged photostat of the rings, the difficulties which had hitherto discouraged ring-workers from the use of hardwoods. His 'chronology' was based very largely on a single 'master oak', cut in 1940, which gave a chart, on the Douglass system, of 373 years; but the chart was extended to 536 years by the use of timbers from Mandan Indian village sites, which were of value in the dating of events in the history of the Mandan people. Light was also thrown on the progressive deforestation of the country. The earliest lodges were built largely of burr oak, with, later, a larger proportion of 'cedar' (*Juniperus scopulorum* Sarg.). Finally the builders were reduced to the use of the inferior cottonwood (*Populus* sp.). It is significant that after the further clearing activities of the white settlers a considerable search was needed before a single tree could be found to give a sequence approaching 400 years.

SOME CRITICISMS.

With regard to the main conclusions about the local climate, reached by Weakly, Will, and others who work along similar lines, although it is most likely that they know their own climate and have reached correct conclusions about it, the means by which they have arrived at those conclusions are very much open to criticism. Even in a dry climate the relation between rainfall and the activity of the cambium is far from simple or direct. Of course, there will be some correlation between ring-width and every important factor influencing growth, including rainfall; and it may well be correct to assume that every drought, long enough to deplete the soil moisture to an extent sufficient to limit cambial activity, will necessarily result in a narrow ring. But it is another matter to assume that every narrow ring represents a drought, or that every broad ring represents a wet year.

A broad ring clearly indicates that all the factors which influence wood formation were somewhere near the optimum level, and a narrow ring indicates that, at the operative times, one or more factors were relatively far from the optimum. Even if we consider only the one factor of precipitation, a mere annual total is of little value, without knowledge of its form, heaviness, duration, and distribution thoughout the year. Then, as the effect is mainly indirect, through the soil moisture, there is the whole complex of the water relationships of the soil to consider, including its organic and biological content of symbiotic, associative, and pathogenic organisms. Also there are all the factors which influence the uptake of soil water into the tree, including the various forms of physiological 'drought', the effects of temperature, of evaporation, and so on. Thus there are brought in, also, nearly all the factors, other than rainfall, which in themselves have a direct effect on growth. At any point in the sequence from rain to cell formation a limitation on growth may appear, and at any point other factors in the environment may intervene directly with the same effect; for instance, extremes of temperature, especially frosts; winds and storms; low and high evaporation; sunlight, including the effect of clouds, sunspots, &c.; tensions and compressions in the trunk and branches; length and continuity of the growing season; the hereditary rhythm and age of the tree; effects of seed manufacture, food reserves, growth activators, and inhibitors; defoliation by insects, fungi, &c.; pollution of the atmosphere and pathological effects generally; and, above all, the effects of competition, and of release from it by suppression, by fire, by disease, and by biological factors, including human felling and management, which seem to have been greatly underestimated.

Even in a dry climate, as Shreve (29) has shown, rain, by wetting the top layer of a desert soil, may lead to a quicker drying out of the soil below, owing to improved capillary action; and Fry and White (12) showed in *Sequoia* that growth can be as much hindered by too much water as by too little. Perhaps such effects may be eliminated by a careful selection of trees from suitable sites, but when the pattern is extended by the use of house timbers, buried logs, &c., this selection is abandoned. The whole argument then depends on the assumption that trees with ring patterns which cross-identify grew upon similar sites and their wood

formation was dominated by the same climatic factor, in this case rainfall, in the same way and to the same extent. That is, the worker assumes that the matching continues consistently to be based in the main upon rainfall or drought effects, and there is no change of emphasis, even over a long period of time, to a pattern dominated to a greater extent by other factors, say widespread defoliation, or the effects of competition and release by selective felling of the dominants at irregular intervals, as determined by wars, pestilences, tribal movements, or other changes in human affairs, or the almost certain change in the effect of rainfall on selected 'master trees', owing to the cumulative influence of leaching on the soil.

One criticism of this general assumption is that it involves in itself the conclusion which is invariably come to in this type of paper, namely that there has been no permanent change in the climate during the period covered by the rings. Another assumption is that there has been no major change in the relative effects of climatic and non-climatic factors.

MAIDEN CASTLE.

A basic weakness about the drawing of climatic inferences from 'dendrochronological' work lies in the small number of trees which provide the data on which such broadly drawn conclusions are based. There is no more reason to suppose that trees which cross-date give a better picture of climatic variations than those which do not; on the contrary, they are more likely to give a distorted one, simply because they are selected for coincident features, some of which may well be non-climatic in origin. This weakness has been avoided by Salisbury and Jane (27) in their comparison of the average width of the annual rings in modern hazel (*Corylus avellana* L.) and oak (*Quercus* sp.) with that of charcoals of the same species from Maiden Castle at Neolithic and early and late Iron Age levels. Large numbers of specimens were examined; nearly 2,000 annual rings from prehistoric charcoals were measured and compared with charcoals made from recent small stems of similar size (e.g. 568 rings for hazel alone). The ring-widths of modern hazel from the chalk of Dorset were found to correlate strikingly with the rainfall during the growing season, over a period of four seasons. The means of the ring-widths, from Neolithic to Recent, showed a slight but consistent increase, although none of the differences approached statistical significance.

Here also, the general conclusion drawn by the authors is that 'objective evidence is furnished indicating that the climatic conditions throughout the period represented were probably essentially similar to those obtaining at the present time'.

In the same paper the conclusion is also reached that in Neolithic times the chalk of Dorset was probably covered with a closed oak–hazel woodland, which has given place successively to a more open vegetation under the influence of leaching and of forest destruction by man. The slight decrease in the size of oak rings from Neolithic to late Iron Age is attributed to increased exposure, and soil erosion due to this effect, rather than to any general climatic change; whereas in hazel the slight but steady increase in widths, if it has any significance, 'would seem to suggest there is a tendency for the climatic conditions to become steadily

more humid'. Elsewhere in the paper 'the density of the stands of trees and/or bushes' is mentioned as a factor which must not be overlooked in assessing the utility of ring-widths as a climatic index.

Thus the paper illustrates the difficulty of drawing even a negative conclusion about climate from ring-width data, however ample. The assumption always has to be 'other things being equal'; but in this Maiden Castle case there is evidence of progressive changes in factors other than climate which must produce some effect unless they can be shown to counterbalance each other. It is probably impossible to estimate the effects on the annual increment of a more open stand, on the one hand, and of increased exposure and soil erosion over such a long period, on the other hand; but the expectation is that in so far as the density of the stand is kept by human interference below that which the trees would adopt under mutual competition in a closed community, the tendency would be towards a larger root system, a bigger crown, and a wider ring. The conclusion would then be that if there is no change in the ring-widths, there must have been a change in the climate sufficient to compensate for the gradual opening up of the stands. This is speculative, of course, but it is no more so than the implicit assumption that such ecological changes, acting over a long period, have had no measurable effect on the rings.

COMPARISON WITH VOLUME INCREMENTS.

A different approach is made by E. W. Jones (21), who compares the mean diameter increment of eight old oak (*Quercus*) trees in the New Forest with the volume increment of mixed silver fir–spruce (*Abies alba* Mill. and *Picea abies* Karst.) forest in the Swiss Jura, and also with the graphs of some 200 increment cores of pine (*Pinus sylvestris* L.) in northern Finland made by I. Hustich and published on the preceding page of *Nature*. All three curves show a marked tendency to rise in the early years of the present century, which corresponds very roughly with a general rise in temperature from about 1890 to 1930 (reported also from America); but the Swiss and English curves (not the Finnish) show severe depressions associated with dry periods culminating in 1921 and 1935, and after 1930 the Finnish and English curves show a general fall, not shown by the Swiss. This author's conclusion is: 'It seems clear that the investigation of the trends of growth shown by trees over long periods, as distinct from the attempts to interpret the peculiarities of individual rings, is a very promising field of work.'

Such trends, however, at least in so far as they relate to climate, must be established on a massive basis of increment measurements covering a large area, such as, for instance, those necessary to make estimates of the volume increment of a number of forests in different localities. In this way only can the effect of local influences be eliminated. Furthermore, the increments must be dated, though not necessarily on an annual basis, so that they can be compared with one another and with the meteorological data. This means that such studies can apply only to contemporary utilized forests, and at most to the period for which increment measurements have been recorded. Nor is the sort of careful tree-ring analysis which is dependent on complete cross-sections likely to supply enough or

suitable data, even from contemporary trees, unless conducted on a very extensive scale. In other words, the method is not likely to provide reliable evidence about the effects of broad climatic changes beyond the period for which direct meteorological records are available.

Within this limitation, however, it would be immensely helpful if the effect of known and recent climatic changes upon tree growth could be established, thus enabling us to eliminate this broad climatic effect from the ring pattern, and so approach nearer to an understanding of the effects of local and hereditary factors which are of more practical importance in forestry. Until the tree-ring record can be 'broken down' in this way, the vast amount of information it surely contains is likely to remain locked up.

IDENTIFICATION OF THE ANNUAL RING.

To abandon the attack on the individual ring is to abandon all hope of interpreting the record which trees leave behind them in their wood, of which record the annual ring is the basis. All tree-ring work, even on the broadest lines, begins with the identification of the annual increment, the usual assumption being, of course, that every sharp line of demarcation, in a seasonal climate, marks the change of the seasons, and not some other check to growth, which would declare itself by a hazy outline. Generally correct as no doubt this is, the occurrence of multiple-growth layers with a sharp outer margin in a single season is being more and more brought to attention (Glock, 14, 15; Glock and Reed, 17); and there is also no certainty that the annual increment always ends with a sharp outline (MacDougal, 25; Glock and Studhalter, mentioned in Glock's review, 16). That is to say, even this first and basic step in all ring analysis cannot be taken without studying the peculiarities of individual rings; and it may be said that, on the whole, it has been the neglect of all other characters except the sharp outline and the width which has constituted the main weakness in tree-ring work.

In the study of other sequences of material which give some record of the passage of time, such as, for instance, the stratigraphical sequence of the rocks, or of pollen-containing peat beds, it is the quality and the content of the different layers, and not merely their thickness, which is relied upon for their identification. Only in tree rings and in varves (glacial clay or silt deposits in lakes) has the relative thickness been the sole criterion from the first; and of varves Sauramo (quoted from Zeuner, 32, pp. 23, 25) writes: 'A better method must be independent of the variation of thickness of the varves, the inconstancy of which is the main source of trouble, and rely upon other characters, inherent in each individual varve or group of varves and more constant than the relative thickness. Such characters in fact exist among the physical properties of the sediments.'

Such characters also exist in tree rings, with their far more complex biological nature, and reside in the relative size, colour and thickness of wall, and distribution of the different types of wood elements. Hardwoods, one would expect, would supply such characters in greater variety than softwoods, and it is because of their complexity that they have been left alone for the most part, by those working on ring-widths. In their simplest form, as seen with a hand-lens on a

softwood with conveniently coloured rings, these characters provide an easy criterion in the balance and distribution of the light and dark zones formed by the large and small elements; the appearance of the summer band is frequently characteristic, and if a quantitative character is needed, the frequency of occurrence of additional or 'false' rings of thick-walled tracheids in a given year's increment may provide it.

MULTIPLE OR ADDITIONAL RINGS.

References to such additional rings are innumerable throughout the literature, from Douglass (6) onwards, but in nearly every case in the earlier work the 'false' ring was regarded as a nuisance and a possible source of error through being mistaken for an annual ring, and material showing too many false rings was rejected from analysis. Douglass, however, mentions that he was able to recognize certain years by their characteristic 'false' rings, and more recently Glock (14, 15, 17) and others in America have been relying increasingly upon such characteristics for the identification of the annual growth layer and the establishment of growth patterns.

As long ago as 1925 an interesting use of frost rings was made by Bailey (3) as a means of dating the effects of the spruce budworm (*Cacoecia fumiferana* Clem.) on the ring sequence, which were often such as would upset the 'dendrochronological' pattern completely. Often, at the base of a badly defoliated tree, an unusually wide ring would be formed in the first year, and the cambium would then become inactive for several growing seasons, forming after that a succession of narrow rings before it returned to normal; just such a sequence, in fact, as supplies the chief data for cross-dating in dendrochronology. But so variable was the effect of the budworm on different trees, and different parts of the tree, that Bailey was unable to date rings only a few years old by counting in from the surface of recently cut young stems. This he achieved, however, by noting the incidence of characteristic frost rings in certain years (confined in the balsam fir (*Abies balsamea* Mill.) to the 6–8 innermost growth layers) and thus establishing the date of an inner ring in addition to the date of cutting of the outside ring. The sequence between them could then be sorted out, and was found, sometimes, to lack completely as many as three annual growth layers in a sequence of only about a dozen years. A similar use of frost rings was made by Glock and Reed (17) as a means of establishing the identity of the annual increment where multiple-growth layers had been formed.

At present the only undeniable record of climatic effect upon the wood is the frost ring, which is clearly recognizable by its qualitative characters: crumpled tracheids, crushed undifferentiated cells, buckled rays, &c. Bailey (4) also distinguished the brownish 'false' rings of resin-bearing cells which are traceable to the feeding of the spruce budworm on the apical shoot, and the shallow oval cavities attributed to the feeding of weevils (*Pissodes dubius*) so that the dates of the growing seasons when these pests were active could be determined from the wood. These are all abnormal characters, in that they are traumatic and therefore provide an easy contrast.

SUPPRESSION OF RINGS.

Evidence is now voluminous as to the suppression, partial or complete, of annual rings by insect attack and other factors. Evenden (11) in a study of the effects of defoliation by the pine butterfly (*Neophasia menapia* Felder) on ponderosa pine (*Pinus ponderosa* Dougl.) found that successive cores taken from 1922 to 1935 from the same trees showed that, following severe defoliation in 1922, and rather less in 1923, many trees failed to add any basal increment for periods from 1 to 11 years. Rubner (26) found a spruce (*Picea*) 95 cm. high, estimated to be about 95 years old, but with only 44 annual rings at the base, i.e. lacking more than half of them; and many others who have examined stunted or suppressed trees could match this experience.

But for every complete suppression of an annual ring there are many cases of partial suppressions. Erlandsson (10), one of the few dendrochronological workers in northern Europe, says (quoted from Glock, 16): 'If we try and deduce the annual variations of climate from the sizes of the annual rings, we meet with almost invincible difficulties.' Similarly, attempts to correlate rainfall and tree growth in the eastern United States have yielded mainly inconclusive results. (Glock, 16, gives a number of references.)

Although Douglass (9) and Glock (13) in Arizona found sufficient uniformity for their purpose in the width of rings at different heights on the trunk, MacDougal (24) and Shreve (28) in California, and Jaccard (22) in Switzerland, found great variability in the relative widths in different parts of the tree. Furthermore, as many authors have pointed out, the only true measure of tree growth is the total increment of volume over the whole tree, of which a linear measurement of the ring-width at one point, or even of the ring area, provides a most inadequate and often unreliable indication.

DISCUSSION.

Altogether, it would seem that outside those regions in which rainfall can be shown to be the general limiting factor on tree growth, the width of the annual ring is one of the least reliable characters which could be chosen, either as an indicator of climatic change or as a means of identifying and dating individual growth layers.

It is true that width is a universal character, and being purely quantitative is well adapted to quantitative presentation. Particularly where the wood structure is poorly preserved, as in carbonized or waterlogged archaeological specimens, the width may be the only character available, and the long sequences of rings sometimes present may compensate for the relatively small number of specimens. But the effects of a complex environment upon so complex an organism as a growing tree are not intelligibly depicted by a single quantitative character.

It is frequently forgotten that the introduction of measurement and statistics into a biological study usually involves an initial act of vast over-simplification in the substitution of abstract, imaginary units for the realities involved. A table of numbers or a graph representing a sequence of ring-widths is a fantastically crude substitute for a sequence of actual rings in a cross-section of a trunk, which in

turn is a most inadequate, two-dimensional, substitute for the sequence of growth-increments in time of the tree. Similarly, a series of figures representing rain-gauge measurements summed over arbitrary periods such as years, or months, is a thing almost comically remote from any rainfall actually experienced by a tree. If symbols representing two such series can be made, by suitable mathematical handling, to show some degree of correlation, it is not a matter of much interest, since it tells us nothing that we did not know. At most, it might justify a guess that rainfall and tree growth are not entirely unrelated. The calculation of a probable error to one or more places of decimals has no bearing whatever on the significance of the figures in relation to anything real, since the relationship of the substituted series to whatever we are trying to study is completely incalculable.

Admittedly such simplifications are necessary to relieve that extremely blunt instrument, the human brain, from the intolerable strain of trying to grasp the true complexity of the situation, and are even more so if simple and intelligible conclusions are to be presented in linear series on the printed page. What is a little odd is the conviction, now widespread, that on such material quantitative work, involving as it does the maximum imposition of the crudities of the human mind on the complexities of the matter in hand, is necessarily more accurate than qualitative work in which the mind is applied at least one step more closely to the material itself.

Fortunately, in the realm of tree-ring studies, the phase of inexpert or ill-considered resort to statistics appears to be on the wane. It is no longer fashionable to extract cycles from ring-measurements or to use them for the establishment of correlations with averaged weather statistics. It seems doubtful whether any certain light has yet been thrown on past climatic conditions by tree-ring work, but on the other hand attention has been directed to some purpose to the study of present climatic conditions and the response of tree growth to them.

The establishment of three Rainfall Types in the Southwest States of America (Glock 14, 15) is a direct outcome of tree-ring studies, particularly those on multiple-growth layers in West Texas. The three types are, briefly, the *California* type, in which a sufficient reserve of water from winter rainfall gives single annual growth layers; the *Texas* type, in which most of the water available for growth comes from intermittent rain during the growing season, giving variable, multiple, and partial growth layers within the annual increment; and the *Arizona* type, which is intermediate.

It seems unlikely that such broad differences in rainfall type will be found in the narrower compass of Great Britain, but very probable that analogous differences may be brought about more locally by soil and site factors. However, we are not yet within striking distance of the establishment of such differences. It is necessary to start at the beginning, with the identification of the annual growth layer and the establishment of a growth pattern in each region and species to be studied. Although we are 30 years behind the Americans in this subject, fortunately the prolonged phase of classical ring-width studies can be eliminated in this country, because the bulk of our forests are too young to provide the necessary sequences, and also it is clear that the effects of management on competition

between the trees is one of the dominant factors influencing ring-width. A. W. G. Lowther, however, has shown here the value of such studies to the archaeologist working on large oak timbers.

It will be of no use to look for some other single, simple, character to replace the ring-width as the universal key to the tree record. It is necessary to look at every species studied, in each region, for the characters which will serve best. In Part II of this paper a study of European larch (*Larix decidua* Mill.) is described, in which it was found possible to identify and date the annual growth layers by means of their qualitative characters, and to simplify the growth pattern for presentation in terms of the frequency of layers of denser wood within the annual increment.

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A CENTURY-OLD FOREST NURSERY IN GERMANY

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SUMMARY.

In August 1949 the author paid a brief visit to the 200-acre forest nursery of Pein and Pein in the district of Halstenbek, near Hamburg. Here on very light sandy soil almost continuous tree crops have been grown for about 100 years. All crops with the exception of pines receive a dressing of farmyard manure as well as nitrogen, phosphate, and potassium fertilizers. Lime is applied only once every 7 to 10 years and the land is then cropped with hardwoods for 2 to 3 years. Normally sowing takes place in April and May, and lining out from July to October of the following year. Single boards with an attached notched metal strip are used for lining out.

IN August 1949 I had the opportunity to visit one of the old-established forest nurseries near Halstenbek, a little over 10 miles to the north-west of Hamburg, associated with the well-known and honoured name of Pein. In this district a large number of privately owned nurseries exist side by side. Together they supply a considerable proportion of the total planting material needed for the German State Forests (1). Before the Second World War some of these nurseries exported vast numbers of tree seedlings to overseas countries, especially South America.

The light sandy soils of the Halstenbek district are acid and extremely low in nutrients, as they are derived from glacial material which has undergone repeated washing and sorting. The country is very flat.

The nursery described below covers over 200 acres and employs about 350 people. It has been in existence for about 100 years and has carried tree crops almost continuously. No systematic green cropping is practised, but in times of food shortage a few arable crops, like potatoes and oats, are grown to eke out the workers' rations. The nursery was practically free from weeds when I saw it.

The conifer species grown are Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* Karst.), Sitka spruce (*Picea sitchensis* Carr.), European larch (*Larix decidua* Mill.), and Japanese larch (*Larix leptolepis* Gord.). Some hardwoods are also grown.

Sowing takes place during April and May, and sometimes as late as June or even July. Experience has shown that earlier sowing would give better results, but as most of the forest planting is done in the spring, it is usually impossible to get the plants lifted, dispatched, and the land prepared in time for sowing in March or early April. All seed is sown in drills with the exception of Sitka spruce which is broadcast. Sitka seed is considered too small for successful drilling. The seed-beds are 4 feet wide, carry 7 drills, and are separated by 1-foot alleys.

In August 1949 most seed-beds were satisfactory but the stand and size of the Sitka seedlings were very poor. The seed for this year's Sitka sowings had been obtained from trees in the Flensburg district. Losses through damping off had been severe, during a season which, in contrast to Great Britain's, was cold and damp.

Unless there is a shortage of land the seedlings are lined out and spend about 18 months in the transplant beds. Root pruning of seedlings before transplanting is considered essential. Lining out is done from July to October with seedlings of from 1¼ to 1½ years, or sometimes up to 2½ years.

When I visited the nursery, lining out of Norway spruce was in full swing (Fig. 1). Immediately after lifting, the seedlings are packed in round baskets, with the tops pointing outwards and the roots towards the centre. When a basket is full, it is covered with matting and brought to the lining-out site. Fig. 2 shows the lining-out spade, the wooden box to which the plants are transferred shortly before lining out, and the single lining-out board. This board consists of a wooden plank to which is attached a metal strip with regularly spaced notches to receive the plants. The spade is quite a heavy implement, wedge-shaped in cross-section and 1 foot wide at the base.

Each worker completes the whole lining-out operation by herself. A trench is made by moving the spade to and fro. When a trench of the length of the lining-out board has been prepared, the single board is placed in position, with the notched metal strip over the trench. Fig. 2 shows a girl inserting the seedlings into the notches—an amazingly fast operation. When a board has been filled, the girl pushes the soil back with her hands and pulls out the board. The lines are about 7 inches apart and the soil between the lines is firmed by treading.

Each crop of spruce, larch, and hardwoods normally receives both dung and fertilizers. Until the end of the war a nearby garrison provided ample supplies of horse manure, but now cow manure has to be transported long distances from farms in Schleswig Holstein. Horse manure is preferred to cow manure because it is warmer and has less residual effect. Compost is not considered very suitable and is used only if no farmyard manure can be obtained. However, the addition of some sort of bulky organic manure is thought essential if the present outturn is to be maintained. Nitrogen, phosphate, and potassium fertilizers are used in addition to farmyard manure. Nitrogen is supplied in the form of 'Kalkammonsalpeter', a granular mixture of ammonium nitrate and calcium carbonate with 20·5 per cent. nitrogen. This fertilizer is similar to but more concentrated than the British product sold under the proprietary name of 'Nitrochalk', with 15·5 per cent. nitrogen. 'Kalkammonsalpeter' is applied as a topdressing in May at a rate of about 2 cwt. per acre. If the season is very wet a second topdressing is applied a few weeks later. To avoid burning of the needles, any granules that may have lodged in the plants are brushed off with a broom or a bunch of spruce branches.

Where it is possible to clear the land in time, Bessemer basic slag is dug into the ground during the winter. Otherwise a high-temperature phosphate, sold under the proprietary name of 'Rhenania', is applied as a topdressing. (No high-temperature phosphate resembling 'Rhenania' is at present available in Britain, though a related product 'silicophosphate' was prepared here during the war.) Both phosphates are used at about the same rate of 1·2 cwt. per acre. Superphosphate is considered less suitable than basic slag or 'Rhenania' phosphate, and is used only if neither of the other two can be obtained.

Potassium is applied in the form of the 40 per cent. potash salt, which is preferred

to the 60 per cent. muriate of potash usual in Britain. The rate of application is about 1·6 cwt. per acre.

Every 7 to 10 years the beds are limed and then cropped with hardwood for 2 or 3 years until the liming effect has worn off sufficiently for the land to be considered fit for such conifers as spruces and larches.

Pines are treated as a class apart. They are grown continuously, without a hardwood break, and are manured with dung only. They never receive fertilizers or lime.

Until recently the nursery possessed little mechanical equipment, but a new pilot seed drill, and a mechanical hoe specially designed and built for use in this nursery, have just been completed and will be tried out during the coming season.

As I was only able to visit this one nursery, I do not know how far the methods described are peculiar to the nursery I saw or to what extent they represent normal German practice.

The methods outlined above are of special interest because they have allowed a high output of seedlings and transplants to be maintained over a very long period on an inherently poor and hungry soil.

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Fig 1

Fig 2

Picea abies Karst. Lining out Norway spruce in the nursery near Halstenbek, Hamburg, Germany. August 1949

PLATE II

THE SUSCEPTIBILITY TO INJURY BY EXPERIMENTAL FREEZING OF STRAINS OF EUROPEAN LARCH (*LARIX DECIDUA* MILL.) OF VARYING GEOGRAPHICAL ORIGIN

By W. R. DAY

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SUMMARY.

Experience in the field shows European larch to be normally susceptible to frost damage when grown in Great Britain. The paper describes fully a series of experiments in freezing in a refrigerator carried out both before and after the Second World War which show frequent significant differences in degree of damage between larch of different provenances. If latitude is held constant, there is a fairly high and significant positive correlation between state of flushing and amount of injury. When elevation is held constant, there is a significant negative correlation between amount of injury and latitude. There is evidence that provenances vary in relative hardiness at different times during the early part of the growing season. Field observation suggests that most of the serious injury to European larch occurs during March and early April and that therefore provenances which when grown in Great Britain are relatively hardy during the late winter and early spring are those likely to be most suited to its climate. The work was carried out with too few provenances for anything more than general suggestions to be made, but results confirm what is observed in the field: in spite of the poor results often obtained hitherto, further work might show that there are strains in the Alps relatively good for growing in Great Britain; though the most reliable strains are likely to be of British origin with, probably, those from the Sudeten Mountains or Poland as next best.

INTRODUCTION.

IN the years before the Second World War the author and T. R. Peace (now Pathologist to the Forestry Commission) were interested to determine experimentally the effect of freezing on European larch (*Larix decidua* Mill.) (3 and 4). It was demonstrated that this species is susceptible to injury by freezing in a refrigerator at temperatures which occur commonly in nature, and that, therefore, European larch is to be regarded as one of the normally frost-susceptible species in this country. Experience in the field in Britain, both in ordinary plantations and in provenance trials, has fully borne this out; but it has also demonstrated that whereas some strains of larch have proved to be highly susceptible, others have proved much less so, and that some strains appear to be relatively resistant to frost injury. Cieslar's demonstration that larch of Sudeten origin was unable to grow successfully at the higher altitudes for this species in the Alps (2), and the success of larch of Scottish origin, as compared with the failure of Alpine strains, when planted together in the Jura mountains, reported by Burger (1), have also provided quite clear evidence that the variability in physiological character, which is now generally recognized as normal for any species of plant, occurs also in European larch. About the same time Münch's papers (7, 8, and 9) appeared, in which he explained the 'larch problem' as a race

problem. This 'problem' was the dying-back and canker associated with *Dasyscypha Willkommii* (Hart.) Rehm, which had prevented to a great extent the successful cultivation of European larch in the European plain and in Britain. With evidence of this type in mind, freezing experiments were begun in 1934 with larch of various seed origins, to see if it could be demonstrated that significant differences in susceptibility existed between them. These experiments were continued until 1939, when the outbreak of war prevented their continuance.

The most important of the earlier joint experiments was that carried out in 1936. As that experiment showed all the points of value it alone is discussed here. Larch of eleven seed origins, as listed in Table II, were tested: there were six freezings; two in the early spring, two in mid-spring, and two in late spring (Table I). Four plants of each provenance were frozen at each of six temperatures in each freezing period, making twenty-four plants of each provenance for a complete trial in any one period. A range of about ten degrees Fahrenheit was covered by the six temperatures (Table I); this was arranged in order that the critical temperature for injury might be determined with reasonable accuracy. It should be noted that the seed was obtained in most cases from ordinary commercial sources, and that the information with regard to the forests in which it was collected was meagre (Table II). Thus the trials were tests of provenances such as were being currently used in plantations.

TABLE I. *Dates of Freezing and Temperature Range, 1936*

27–31 March	15–25°
6–9 April	15–25°
27–30 April	17–27°
4–8 May	17–27°
18–23 May	19–29°
2–6 June	19–29°

TABLE II. *List of Provenances used, 1936*

A. Silesia (Sudeten) (2,000–3,100 ft.)
B. Hautes Alpes, Briançon, France (6,600 ft.)
C. Longmore Estate, England
D. Silesia (Sudeten)
E. Hautes Alpes (2,800 ft.)
F. Munster, Switzerland, 3,900 ft.
G. Central Alps, valley of Eysack-Isarco (2,300–2,900 ft.)
H. Inn Valley, N. Tyrol (1,900–2,600 ft.)
I. Tyrolese Alps
K. Strathyre, Perthshire
L. Swiss Alps

The freezing scores are shown graphically in Fig. 1: they represent the summation over each of the six treatments in each freezing period of the mean freezing score per plant treated. These scores are based upon a numerical weighting of the injury received, according to the following scale.

Nil	*Slight*	*Moderate*	*Severe*	*Dead*
0	1	4	9	16

No plants were actually killed, so that the 'dead' category did not arise. The critical temperature for injury was not determined by the freezing score but as that temperature at which half the plants treated, that is two out of the four for each provenance, were injured. Critical temperatures determined in this way are unsatisfactory, if only because it is necessary to consider the severity of the injury

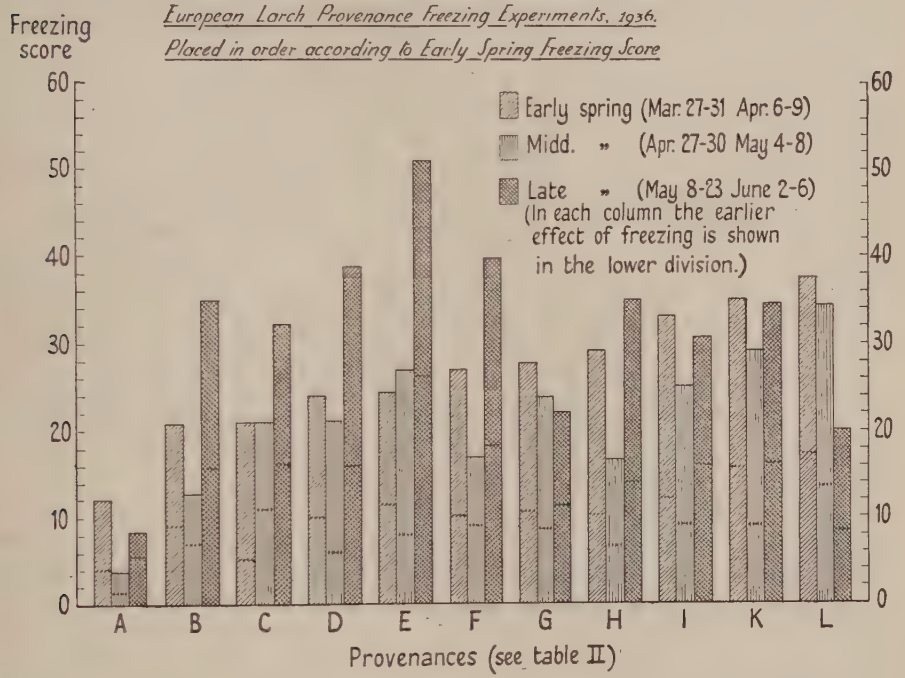

FIG. 1

received as well as the number of plants injured in order to make a true comparison. Also the variations in susceptibility within each provenance may be so great that four is too small a sample to give a result of any great accuracy, although when the whole range of freezings done in any period is examined, it can be seen where, approximately, the critical temperature for serious injury lies under the conditions of the experiment. For these reasons the total freezing score in each period has been used for comparison between the various provenances.

Fig. 1 shows that in the early spring there is a considerable range in severity of injury between the different provenances, but that this order in severity of injury is not maintained either in mid-spring or in late spring. For example, the provenance most susceptible to injury in early spring (Swiss Alps) is shown to be one of the least susceptible in late spring. The results also show that there is not necessarily any constancy in susceptibility between provenances which come from different places in the same geographical region; the differences between the two French and the two Silesian strains provide examples of this.

The importance of this work was, therefore, that it confirmed experimentally what had been suggested by field observations, viz. that there are significant

intra-specific variations in frost susceptibility in European larch, and suggested that even within one geographical region significant variations in susceptibility might occur between strains from different localities.

The outbreak of war completely interrupted the further development of the work, but in the autumn of 1945 an unusual opportunity for its resumption occurred. War conditions had made possible the collection by neutral agencies of European larch seed of a large number of different provenances. As a result there existed at that time (1945), in the Forestry Commission's nursery at Kennington, near Oxford, stocks of European larch of thirty-seven different geographical strains, and also two lots of Japanese (*Larix leptolepis* Gord.) and one of Siberian larch (*L. sibirica* Ledcb.). The locality in which the seed of the Japanese larch had been collected was known in only one case, Denmark. European larch was represented from the Italian, Swiss, Austrian, and Bavarian Alps, and also from the Czechoslovak–Silesian region, within the area of its native distribution. No Polish types were represented. There was also larch raised from seed collected outside the area to which it is native. Such came mostly from the German Plain, but one strain was of Swedish origin, though originally stemming from Dunkeld in Scotland, and another had been collected at Aldroughty in Morayshire, Scotland. All these various strains of larch had been collected for the purpose of establishing sample plots, as part of a provenance experiment organized by the International Union of Research Organizations.

The presence of plants of so many different provenances obviously provided an opportunity, which was not likely to occur again for some time, of testing by means of freezing in the refrigerator the relative susceptibility of at least some of the strains to injury by low temperature. Accordingly arrangements were made with the Forestry Commission's research branch for plants of 19 of the 40 strains to be set aside for this purpose. These 19 included the 2 lots of Japanese larch; 2 strains each from the Italian and Swiss Alps; 5 in all from the Bavarian and Austrian Alps; 3 from Czechoslovakia; 3 from the German Plain, including 1 from Upper Silesia; and the Swedish and Scottish strains. The information available regarding these lots of larch, taken mainly from the printed leaflet issued with regard to the provenances, is given in Table III. The Swedish and Scottish strains and the larch from the German Plain were obviously from seed collected from trees which were not indigenous to the region in which they grew; but the others have been taken to represent stocks truly indigenous to the places where the seed was collected.

THE GENERAL METHODS AND AIM OF THE EXPERIMENTS.

The experimental plants were put into pots and were kept in the open until the time for freezing. They were then placed in the refrigerator at the appropriate temperature and kept therein at this one temperature, for 8 hours. Thereafter the plants were taken out of the refrigerator and allowed to stand indoors for some hours before being sent back to the nursery, where they were kept in a large frame to protect them from further injury by naturally occurring frost. Assessment of injury was carried out in June.

TABLE III. *Larch Provenances*

Mark	*Region of origin*	*Place*	*Altitude (metres)*	*Approx. latitude of region (degrees)*	*Remarks*
C23	Italian Alps	Lago	?	46	..
C25	„ „	Val Vanosta	1,000–1,200	..	..
D26	Swiss Alps	Lotschental (Wallis)	1,500	47	..
D27	„ „	Graubünden (Unter-vaz)	430–650	47	..
A4	Austrian and Bavarian Alps	Innsbruck	850–950	47	..
A5	„ „	Krumbach	600	..	..
K8	„ „	Murau-Murau	900–1,000	47·30	..
A14	„ „	Standard Waldstein	500–600	..	..
B18	„ „	Steinach-Gries	1,800–2,000	..	..
I45	Sudets. Bohemia	Hrottowitz	410	..	..
I49	„ „	Parkowitz	350–400	49–51	..
K52	Slovakia	Murau, Liptovsky Horadak	960–1,045	49–51	..
F31	German Plain	Neumünster (Schleswig Holstein)	30–70	54	..
F32	„ „	Proskau, Upper Silesia	?	51	..
F36	„ „	Stolp (Pommern)	25–30	54·30	..
K54	Sweden	?	?	57·30?	Original seed from Dunkeld, Scotland
..	Scotland	Aldroughty, Moray	?	57·30	..
E28	Denmark	?	?	..	Jap. larch
–56	?	?	?	..	Jap. larch seed from Wolfgang, Cologne

Field observation has indicated that frost injury to European larch at the beginning of the growing season commences not later than the latter part of March, and that often by the middle of April most of the injury which is sufficiently severe to cause serious die-back has taken place. Usually such injury becomes obvious owing to the discoloration, wilting, and cessation in growth of the leaves on the dwarf shoots, when they have just appeared or are $\frac{1}{8}$ to $\frac{1}{4}$ inch long. It is known, however, that serious injury owing to spring frost may take place at any time until the period of dangerous frosts is over. This is usually in the middle or latter part of May, in most places in England and Wales, though in frost hollows or in naturally frosty regions, such as much of the Breckland in East Anglia, situations may exist in which dangerous ground frosts are liable to occur

almost at any time throughout the year. With these possibilities in mind it was decided to treat each of the strains of larch once in each of the months of March, April, and May. The March freezing was arranged to take place when buds showed green on the earlier but were unbroken on the later flushing plants. Treatments at three different temperatures were given in each month, these being arranged so that the lower temperature was below and the higher temperature above the critical temperature for injury as estimated by Day and Peace in work previously carried out (3). The dates and temperatures of treatment are set out below:

	March			*Apr.*			*May*		
Date	15	16	18 & 19	15 & 16	18	19	15 & 16	18	19
Temp. (° F.)	10	13	16	19	22	25	22	25	28

The state of each plant, as regards flushing, was noted immediately before it was placed in the refrigerator. The states of flushing were classified as follows:

A. Buds unbroken.
B. Buds just broken.
C. Buds broken, needles just separating.
D. Buds broken, whorl of needles open but needles not fully grown.
E. Leaves fully flushed.

These stages applied only to the dwarf shoot buds in March and April; but in May the long shoot development had begun.

The number of plants treated at each temperature was four of each strain, so that twelve plants of each lot were treated during each month. A larger number would probably have been desirable, but it was not possible to accommodate more plants; also, in cases where the total number of plants of a particular provenance was small, it would have been difficult to have obtained more without spoiling the field plot for that particular strain. The amount of injury received was assessed by estimating the proportion of buds killed. Usually this was judged by eye, but counts were made at intervals in order to check the eye estimates. Dead trees were counted as having 100 per cent. of the buds dead; trees which had been cut back to their base but had shot again as having 99 per cent. of the buds dead. The total number of marks it was possible to receive, for any lot of four plants of any strain, at any treatment, was 400: this would imply that all four plants were dead. Table IV gives the freezing scores so assessed. It shows that not only is the range of score over the different strains of larch very great but many of the differences may be very considerable. These scores are summarized in Table IV as average scores per plant, for each strain of larch, for each set of treatments. The scores are again grouped according to regions, and it is plain that on the average the larch from some regions have suffered very much less damage than the larch from other regions. Within those samples which come from the area to which European larch is indigenous, the Swiss and Sudeten strains have the lower scores; the two strains from the Italian Alps relatively high scores; while the Austrian–Bavarian group shows a great range in score, some having relatively low and some high scores. The other samples, excepting that from Slovakia, must necessarily have been raised from trees which were introduced to the region in

TABLE IV. *European and Japanese Larch: Freezing Scores*

	Mark	Region of origin	10°	13° 15–19 March	16°	19°	22° 15–19 April	25°	22°	25° 15–19 May	28°	Totals
European larch	C23	Italian Alps	229	70	72	384	315	170	396	111	81	1,828
	C25	" "	184	170	105	310	210	75	348	130	165	1,697
	D26	Swiss Alps	85	77	55	135	95	125	130	165	83	950
	D27	" "	37	44	29	310	155	122	64	87	73	921
	A4	Austrian and Bavarian Alps	152	51	46	365	212	141	295	7	10	1,279
	A5	" "	132	85	141	322	159	55	119	13	21	1,047
	A8	" "	204	13	9	400	235	117	197	44	41	1,260
	A14	" "	307	145	126	255	215	157	280	169	225	1,879
	B18	" "	260	320	305	285	217	217	207	31	80	1,922
	I45	Sudets. Bohemia	122	155	27	125	39	201	23	37	1	730
	I49	" "	33	127	69	215	167	179	110	19	32	951
	K52	Slovakia	47	218	177	400	15	20	87	15	24	1,003
	F31	German Plain	138	307	140	237	38	42	184	32	10	1,128
	F32	" "	181	166	110	229	160	51	295	154	38	1,384
	F36	" "	100	182	159	334	146	40	254	45	10	1,270
	K54	Sweden	86	63	50	199	179	61	388	87	50	1,163
	Scots	Scotland	67	265	240	280	275	270	140	160	400	2,097
Jap. larch	E28	Denmark	182	122	25	225	145	115	182	52	8	1,056
	–56	?	120	212	162	399	400	400	260	191	104	2,248
	Totals		2,666	2,792	2,047	5,409	3,377	2,558	3,959	1,549	1,456	25,813

TABLE V. *Average Monthly Freezing Scores per Plant*

Region	*Mark*	*Freezing score*			*Species*
		March	*April*	*May*	
Italian Alps	C23	30·9	72·4	49·0	European larch
" "	C25	38·2	49·6	53·6	" "
Swiss Alps	D26	18·1	29·6	31·5	" "
" "	D27	9·2	48·9	18·7	" "
Austrian and Bavarian Alps	A4	20·7	59·8	26·0	" "
" "	A5	29·1	44·6	12·7	" "
" "	A8	18·8	62·7	23·5	" "
" "	A14	48·2	52·2	56·2	" "
" "	B18	73·7	59·9	26·5	" "
Sudets. Bohemia	I45	25·3	29·6	5·1	" "
" "	I49	19·1	46·7	13·4	" "
Slovakia	K52	36·8	36·2	10·5	" "
German Plain	F31	48·7	26·4	18·8	" "
" "	F32	38·1	35·8	40·6	" "
" "	F36	36·7	43·3	25·7	" "
Sweden	K54	16·6	36·6	43·7	" "
Scotland	..	47·7	68·7	58·3	" "
Denmark	E28	27·4	40·4	20·1	Japanese larch
?	–56	41·2	99·9	46·2	" "

which they grew, and so have not the same interest as the imputed indigenous strains. However, the samples from the German Plain show moderately severe damage; the Swedish strain is similar, except that it appears to be relatively hardy in March, and the Scottish strain appears to be decidedly susceptible to injury. The two strains of Japanese larch (*L. leptolepis* Gord.) are worthy of notice. The Danish strain is to be classed with the less susceptible strains of European larch; but the strain of unknown geographical origin showed very marked susceptibility to frost injury.

It is plain that it is not possible to make any adequate comparison, upon a regional basis, between the various freezing scores; the number of samples in each is too few. On the whole, however, the results agree with past experience and opinion. Thus Tschermak (11) has stated that the physiological strain of European larch varies throughout the region of the Alps according to the place within the region and the altitude at which the larch is situated. There are nine samples in the Alpine groups: if all are taken together they show very great variability in their freezing score. It is unfortunate that no Swiss strain, which has proved to be very susceptible to frost injury in Britain (e.g. Münsterthal, or Laatsch), was among the strains from which the samples were chosen: but it is reasonable to suppose that were the larch which is native to Switzerland sampled upon an adequate basis, a variability similar to that exhibited by the Austrian–Bavarian group would be found. Val Vanosta (C25, Italian Alps), however, is a district from which larch seed has been obtained and has proved highly frost susceptible in Britain. The Czechoslovakian larches appear as some of the more resistant, with

moderately low or low scores, and this is in accordance with experience in Germany (7, 8, and 9) and also, in part, in Britain. The Swedish larch is also among the better strains, especially in March and April. There is no experience in Britain of this strain, but larch raised from the plantations from which the strain originally stemmed has consistently proved to be among the better provenances. It is of considerable interest that the one strain of Scottish origin proved to be one of the more susceptible to injury. The results set out in Fig. 1 provide another instance, for the one Scottish strain, Strathyre, was consistently one of the more susceptible. This is not in accordance with general experience in Britain of European larch raised from Scottish seed, but it serves to stress an obvious fact, that among plantations of any introduced and variable species grown from seed of uncontrolled provenance, it is highly probable that great variations in physiological character will occur. On the whole, then, while the result of one small experiment of this type must not be made to prove too much, it may be taken that not only are there significant differences between larches of varying provenance, as judged by freezing in a refrigerator, but these differences are such as might be expected from experience in the field.

THE RELATION BETWEEN SUSCEPTIBILITY TO FROST AND GEOGRAPHICAL AND TOPOGRAPHICAL POSITION.

It has long been recognized that the physiological constitution of a widely distributed species of plant varies throughout the range of its distribution. It is reasonable to assume that European larch is not different in this respect from other species of tree, such as, for example, Scots pine (*Pinus sylvestris* L.): indeed, Münch's view (7, 8, 9) of the larch problem as a 'race' problem depends on this. If attention is confined to the Alpine and Czechoslovakian strains of larch, among those sampled, and variation with change of longitude is assumed to be unimportant, the principal geographical variations with which change in physiological constitution may be expected to occur will be changes in latitude and elevation. These geographical general data are actually all that are available; it is plain, however, that within a great mountain region such as the Alps, factors of local climate determined by variations in relative elevation, aspect, and exposure, and possibly also soil, might be of considerable importance. These have for the moment to be put on one side, but it must be remembered that inability to take them into account may tend to obscure the real significance of any variation which occurs with change in latitude and in elevation above sea-level.

There were only two ways, within the limits of this work, in which variations associated with changes in latitude and altitude could express themselves. The freezing score might show a regression with either type of change, and also might vary according to date of flushing of leaves. It is well known that among plants of any one provenance those which flush the earlier are usually the more susceptible to spring frost injury. It was for this reason that the state of flushing of each plant was observed before freezing. The flushing classes enumerated above were given the following numerical weights, $A = 1$, $B = 2$, $C = 3$, $D = 4$, and $E = 5$. It was possible to give flushing scores to each provenance by the use of these weights,

and so to obtain a numerical value for comparison with the freezing scores and with the data for latitude and elevation. The flushing scores, grouped according to regions, are given in Table VI.

TABLE VI

Region	Mark	Flushing scores			Species
		March	April	May	
Italian Alps	C23	24	49	60	European larch
" "	C25	29	54	60	" "
Swiss Alps	D26	18	52	59	" "
" "	D27	18	47	57	" "
Austrian and Bavarian Alps	A4	18	43	58	" "
" "	A5	22	53	59	" "
" "	A8	18	47	60	" "
" "	A14	18	35	51	" "
" "	B18	24	41	54	" "
Sudets. Bohemia	I45	18	41	54	" "
" "	I49	17	50	58	" "
Slovakia	K52	21	48	57	" "
German Plain	F31	22	52	54	" "
" "	F32	20	49	59	" "
" "	F36	22	53	59	" "
Sweden	K54	22	60	57	" "
Scotland	..	13	33	34	" "
Denmark	E28	20	55	60	Japanese larch
?	-56	24	48	58	" "

In order to compare the different provenances, the intercorrelations between the four factors, freezing score, flushing score, elevation of site, and latitude of region, were calculated for the eleven provenances for which the elevation of the forest area of origin had been given (Table III). (Where a range in elevation had been given, the calculations were made on the mean elevation.) The total correlation coefficients are given in Table VII. The number of observations is so few that only moderately large correlations appear significant. It is obvious, however, that the March treatments are distinguished from those for April and May by showing much higher and more significant correlations between freezing score and the remaining factors. The indications are plain that under the conditions of this experiment frost occurring during the beginning of the flushing period is that which is most likely to bring out differences between provenances in their susceptibility to frost injury.

Relevant partial correlations for the March freezings are given in Table VIII. These are of more interest than the total correlations in that they indicate more truly the relationships which exist between pairs of factors. Thus they show that when freezing score is considered with one of the geographical factors, the other being held constant, the most significant correlation is with latitude. The negative correlation coefficient indicates that under the conditions of treatment the amount

TABLE VII. *Total Correlation Coefficients for European Larch Freezings*

March

	4	3	2
1	−0·68	+0·53	+0·63
2	−0·40	+0·65	..
3	−0·62	..	..

April

1	+0·001	+0·20	−0·16
2	−0·00003	+0·012	..
3	−0·62	..	..

May

1	−0·026	+0·25	−0·19
2	−0·0054	+0·075	..
3	−0·62	..	..

Factors

1 = Freezing injury score.
2 = Flushing score.
3 = Elevation in metres above sea-level.
4 = Approx. latitude of region of origin.

For 9 degrees of freedom (11 pairs of observations) r is significant above 0·60 if $P = 0·05$ and above 0·52 if $P = 0·1$.

TABLE VIII. *Partial Correlations, European Larch, Freezing Experiment, March Data*

Freezing, Elevation, Latitude

$r_{13·4} = +0·33$
$r_{14·3} = -0·65$

Flushing, Elevation, Latitude

$r_{23·4} = +0·59$
$r_{24·3} = -0·0056$

Freezing, Flushing, Latitude and Elevation

$r_{12·3} = +0·33$
$r_{12·4} = +0·81$
$r_{12·34} = +0·84$

Factors

1 = Freezing injury score.
2 = Flushing score.
3 = Elevation above sea-level.
4 = Approx. latitude of region of origin.

For the first-order correlations r is significant above 0·63 if $P = 0·05$ and above 0·55 if $P = 0·1$; for the second-order correlation r is significant above 0·67 if $P = 0·05$ and above 0·80 if $P = 0·01$.

of injury became less on the average as the origin of provenance became more northerly. If flushing score is similarly examined, the partial correlation with latitude becomes entirely insignificant, but that with elevation remains appreciable and suggests that a significant relationship may exist. The differences between the partial correlations of the freezing and flushing scores with the geographical factors suggest that the relative susceptibility to frost injury of different larch provenances may be strongly influenced by inherent characteristics other than those which find their expression in date of flushing.

The relationship between flushing state and amount of injury by freezing is illuminated to some extent by the appropriate partial correlations in Table VIII. The partial correlations between freezing and flushing scores, one only of the geographical factors being held constant, indicate that the relationship between flushing state and freezing injury is more obscured by change in latitude than by change in elevation ($r_{12 \cdot 3} = 0{\cdot}81$; $r_{12 \cdot 4} = 0{\cdot}33$). This supports the indication, already discussed, of the relatively significant correlation between latitude and freezing score. The partial correlation between the two scores, both the geographical factors being held constant, is greatest of all ($r_{12 \cdot 34} = 0{\cdot}84$), but the increase on the first-order correlation ($r_{12 \cdot 3}$) is not significant. The relationships indicated suggest that, if it were possible to eliminate within the plants those characteristics which are associated with change in geographical position, a much clearer correlation between injury by freezing and state of flushing would be observed than is the case when a variety of different provenances is considered.

The value of these results is limited by the small number of observations, but they do suggest certain reasonable conclusions of both practical and theoretical importance. The first is that, within the range of the observations, larch raised from seed from the more northerly latitudes is more likely to be frost-hardy in England than larch raised from seed from the more southerly latitudes. The second is that it is possible but not proved that at any given latitude larch raised from seed from the lower elevations is more likely to be frost-hardy than larch from seed from the higher elevations. Thus it would appear that the most important of the clinal variations which determine the relative value of a particular provenance of larch seed (obtained from within the part of its native area of distribution which has been represented in this work and from which has come most of the seed for European larch raised in Britain) is that associated with change in latitude. The result of provenance experiments in Britain undoubtedly support this conclusion, which seems to be clearly in line with that reached by Münch (7, 8, 9) for Germany.

THE PERIOD OF SPRING IN WHICH MOST INJURY IS LIKELY TO OCCUR.

An examination of Table IV shows that, on the whole, the greatest degree of injury incurred in any one set of treatments took place with freezing at the lower temperature. There are some marked individual exceptions, such as Aldroughty (Scotland) at 10° F. in March and at 28° F. in May, which it is impossible to explain on the basis of the limited amount of work here discussed. However, there are fairly numerous examples in which a high score at the lowest temperature is followed by much lower scores at the two higher temperatures. This indicates that a large change in the amount of injury received may occur with only a few degrees rise or fall in temperature, and shows how greatly slight differences in temperature may determine the amount of injury which any particular provenance receives. The freezing scores for March show that some provenances, of which Steinach, Waldstein, and Aldroughty are the most prominent, were liable to severe injury at the time of freezing, with air temperatures indicating 16 to 22 degrees of frost, Fahrenheit. In April, however, severe injury is common and fairly severe injury practically general at the lower temperature (19° F.), while appreciably severe

injury is frequent at the two higher temperatures. It is plain, in fact, that in this experiment the temperatures were so chosen that April was the month in which the most severe injury usually occurred. What actually would happen in nature must depend, of course, on the type of weather concerned.

On the whole these results agree with what is to be observed in the field. There is a paucity of observations for March, so far as the writer is concerned; but inspections of diseased European larch plantations made between the end of March and the middle of April have repeatedly revealed that severe injury had already occurred, as shown by the dying of the partly flushed needles on the buds of dwarf shoots, on twigs girdled by frost injury. Often these needles were not more than 1 or 2 mm. long. This is the stage of flushing to be expected, on the average, during the latter part of March or the beginning of April in many places in England and Wales. It should be quite plain that the actual importance of any frost, at any time during the spring, will depend on its severity in relation to the condition of the trees. For this reason it is impossible to prophesy exactly what will happen in the field; but on the whole the severity of frosts decreases as the spring advances, somewhat after the manner of the temperatures chosen in the experiment. Moreover, the temperatures used are within the range of those which occur naturally. So far as European larch is concerned, the unfortunate thing is that in Britain its susceptibility to frost begins before the winter is over, and continues without intermission until the season of frosts is ended. Japanese larch reacts in a similar way to European larch, so far as can be told from the two samples treated. It has been known for some time that occasionally Japanese larch suffers from frost injury in the field, with extreme severity, sometimes much more so than adjacently occurring European larch. The very great difference in degree of susceptibility between the two Japanese larch strains treated, the one being extremely susceptible, the other on the whole resistant to injury, provides a possible explanation of these rather exceptional occurrences. It is evident that provenance of seed is of importance with Japanese larch as well as with European.

Further points of interest are shown by the diagrams in Fig. 2. These show by means of graphs the change in mean freezing score per plant per month for each of the provenances treated. Irrespective of their relative susceptibility, the provenances fall into three main types. The largest group shows relatively low freezing scores in March and May and a relatively high score in April. Of the two smaller groups, one consists of provenances which have a relatively low freezing score in May, as compared with the two earlier months; while the other, on the contrary, has the lowest score in March and the highest in May.

Further experience is needed before larch of varying provenances can be classified into groups according to their relative susceptibility to frost injury at different times of the year; but the results exhibited, which agree with those obtained in 1936 (Fig. 1), certainly do suggest that variations in susceptibility may be characteristics of importance in determining the value of a particular strain of larch for introduction as an exotic. It seems to be quite clear, for example, that in Britain low susceptibility to frost in March and April is much more important

than low susceptibility in May, although sometimes very severe injury may result from May frosts. Strains which are highly susceptible in March, as No. B18 Steinach shows itself to be in this work, are clearly quite unsuitable for many situations in Britain. Strains which are highly susceptible in April are hardly more suitable, for it is during these months that so much serious injury takes place.

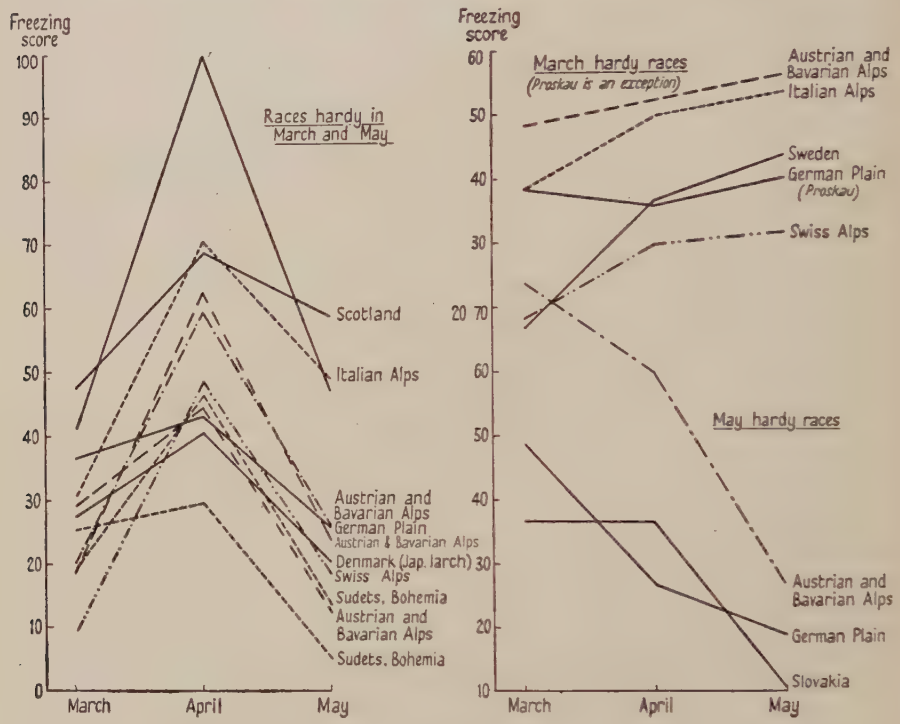

FIG. 2

DISCUSSION.

The first to try experimentally the effect of moving a strain of European larch to a climatic situation markedly different from its native situation seems to have been Cieslar (2). He transplanted larch of Sudeten origin to the higher zone to which this species attains in the Alps, and found that although the Sudeten larch retained at first their faster rate of growth, as compared with the indigenous Alpine strain, they died within a few years. It could only be concluded that they were physiologically different from the Alpine strain. A second interesting provenance experiment was carried out in Switzerland by Engler (5), and was later reported on by Burger (1). Four Swiss Alpine strains of larch and one Scottish strain were planted in the Jura Mountains, which are outside the natural habitat of larch and have a more maritime climate than that habitat. Significant differences in growth and form were observed between the different provenances; the Swiss strains eventually became heavily diseased but the Scottish strain was affected relatively lightly. There have been a number of other provenance experiments

with this species; but they have been concerned with shape and form of stem and crown, and rate of growth, rather than relative susceptibility to disease, and so are of comparatively little concern here. However, the observations cited are sufficient to show that, firstly, a strain of larch which will grow healthily in one part of the native range of the species may not grow healthily in another; and secondly, that if various strains are moved to a given point outside the native range of the species, some may succeed much better than others. The key factor in both cases would appear to be the relative physiological suitability of the strains moved to the climatic conditions in the new habitat.

Since 1928 various European larch provenance trials have been laid down in Britain. One of these has been reported on by Varma (12). He shows that very significant differences in rate of growth may occur between different strains of European larch when grown together in one place. Others have previously obtained the same result. Some of the best examples are found in the paper by Rubner (10), in which he describes fairly extensive provenance trials carried out near Tharandte and in the Erzgebirge. His results show that in these trials the faster growing races came from the Sudeten and Tatra Mountains, Poland, Scotland, and the lower elevations in the Alps; those of medium growth rate were Alpine of middle elevations; while the slow growing types came from high elevations in the Alps. Varma's more limited data fit in with this scheme, and it is believed that when the data are published the British provenance experiments will give generally similar results.

Experience in Britain has been that even the better strains of European larch suffer seriously from the 'larch disease', when grown in markedly unsuitable situations. The strains which have shown general susceptibility and often catastrophic die-back when grown in situations in which more suitable strains have thrived have been Alpine, e.g. strains from Münsterthal, Laatsch, and Vintschgau; and the more suitable strains have been of Scottish origin, or naturally regenerated, or sometimes of Silesian or Czech origin. It is believed that Polish larch may also prove to be good in Britain (6). The fundamental factor determining suitability is resistance to frost injury; but the examination of data from provenance trials in which the same strains have been planted in situations differing significantly in fertility suggests that susceptibility to frost injury may be correlated with characteristics determining efficiency in photosynthesis, and so vigour of growth. Thus of the four strains in the trials worked on by Varma (12), the slower growing ones from the Inn Valley and Trentino have proved to be the more susceptible to larch disease, while the faster growing ones from Scotland (Darnaway) and Bohemia have proved to be the more resistant. (This is particularly clear also in the Brecon Forest plots, which were not examined by Varma.) It is interesting to note further that his data show that the differences in rate of growth between the provenances are greatest in the less fertile of the two sites he examined, viz. Halfway Forest. Thus it may be a characteristic of susceptible strains that they show a different regression of vigour of growth with decreasing fertility, as compared with resistant strains. The effects of climatic changes due to change in elevation and exposure are included here as an aspect of

fertility, and growth factors correlated with length of day and intensity of insolation plainly might be of importance. It does not necessarily follow, of course, that the factors which determine the manner in which vigour of growth changes with change in fertility are the same as the factors which determine frost susceptibility; but there are certainly suggestions that these factors are often associated. Thus it seems to be quite clear that when larch provenances are transferred to a relatively northerly latitude, those which are native to or have been selectively bred in such latitudes are consistently the more vigorous; and field experience and the experiments described show that usually they are also the more frost-hardy. This is a matter of some importance, for it means that it should be possible to select strains of European larch which show vigour of growth over a wide range of fertility and at the same time are frost-hardy, and because of this are relatively free from die-back and canker.

It is being realized today that efficient forestry is not possible unless the variability of the species is understood, particularly when exotic species constitute the main economic crops, as in Britain. It has always been difficult experimentally to examine such variability within a relatively short time, and so to obtain quickly a survey of its general trends. The work described here suggests that it may be possible to examine intra-specific variability in regard to its reaction to the climate at any one point, in a relatively speedy manner and in such a way that general trends within a species may be determined. In order to do this it is necessary to be able to handle a relatively large number of plants, for otherwise adequate proof of intra-specific regression can never be obtained. One of the difficulties in the past, with provenance trials, is that they have been carried out without the preliminary knowledge which suitable investigations could give. The result has been that to far too great an extent each provenance tested has been regarded as an isolated unit instead of what it really is, viz. one point within a complex variable, within which again the general trends can be realized, at least to some extent. Experimental techniques such as that of freezing may thus be used to determine within which part of the range of a species the more suitable strains are likely to be found, and on this basis the efficiency of field trials should be greatly raised. A concomitant and equally great advantage is that such work will develop an improved idea as to what a species really is, when regarded physiologically. Had the true character and requirements been known for some of the strains of European larch widely used in Britain, it is inconceivable that they would have been imported into this country, even though their seed happened to be available in large quantities.

SUMMARY.

1. This paper describes the results of freezing experiments carried out both before and after the Second World War, on different provenances of European larch. It is shown that significant differences frequently occur between these provenances in regard to susceptibility to frost.

2. In the post-war work the provenances were treated three times, once in each of the months of March, April, and May. The March treatment, which was

made when the buds were just beginning to burst, was that which revealed best the differences between the provenances.

3. Correlations for the March treatment have been examined, between amount of injury, state of flushing, and the elevation of the forest above sea-level and the latitude of the region from which came those provenances believed to be indigenous. It is shown that:

(*a*) If latitude is held constant there is a fairly high and significant positive correlation between state of flushing and amount of injury.

(*b*) When elevation is held constant there is a significant negative correlation between amount of injury and latitude. The corresponding correlation with elevation, latitude being held constant, is not significant.

(*c*) There is an appreciable but not significant correlation between state of flushing and elevation, latitude being held constant. Further work might show that strains from the higher elevations in any one region tend to flush earlier than those from the lower elevations, under conditions such as those of this experiment. There is no correlation indicated between state of flushing and latitude, elevation being held constant.

4. These results suggest that, within the region between the Southern Alps and the Sudeten Mountains, from which the provenances examined statistically were obtained, those from the more northerly latitudes are likely to show less susceptibility to frost injury than those from the more southerly. This seems to be in accordance with field experience in Britain.

5. There is also evidence that provenances vary in relative hardiness at different times during the early part of the growing season. Thus under the conditions of the experiments, most strains showed greatest injury in April; but in some this maximum occurred in March, and in others in May. Field observation suggests that most of the serious injury to European larch occurs during March and early April, in many cases. This being so, provenances which are, when grown here, relatively hardy during the late winter and early spring are those which are likely to be most suited to the climate of Britain.

6. This work was carried out with too few provenances for anything more than general suggestions to be made. It can be said, however, that the results obtained conform with what is observed in the field. Much more work and on a much larger scale is required for any detailed examination of the variability of European larch. Such work might show, for example, that there are strains in the Alps which are relatively good for growing in Britain; and indeed the data suggest this. However, there are at present no means of ascertaining where such strains are to be found. Past misjudgement in choice of strains to be imported has been due largely to this lack of information.

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ENGLISH TREE NAMES AND THEIR ORIGINS

By H. L. EDLIN

SUMMARY.

Considerable confusion exists in English forest and timber-trade literature because the same English names are applied to various trees and timbers which, botanically, are quite distinct. This situation arises because, during the past 400 years, English-speaking peoples have been introduced—through exploration, overseas settlement, and international trade—to far more trees than their language has root-words to describe. Some names are derived from Anglo-Saxon roots, others from foreign languages, and others are comparatively recent combinations of existing English words. A list of standard names for commercial timbers has been issued by the British Standards Institution, and a similar list, for both trees and timbers, by the American Joint Committee on Horticultural Nomenclature. Neither list is entirely suited to the needs of foresters in all the English-speaking countries, and it appears unlikely that international conformity will ever be attained. Nevertheless, it is considered desirable that each timber-tree should have a 'standard forest name' in English, quite distinct from its scientific name in Latin.

IT must be a matter for regret among foresters that such widespread confusion exists in the definition and application of common English names to forest trees and their timbers. For although the Latin scientific names serve us well, we must admit that they are not common currency among forest workers, the timber trade, the general public, or even in our own conversation and forest literature. If such a word as 'cedar' were invariably applied to trees of the genus *Cedrus* and their timbers, it could always be used without specifying whether we mean Lebanon cedar, *Cedrus libani* Loudon (Syria); or Port Orford cedar, *Chamaecyparis lawsoniana* Parl. (Oregon); or cigar-box cedar, *Cedrela odorata* L. (Brazil); or pencil cedar, *Juniperus virginiana* L. (Virginia); or a number of other unrelated tree species.

This example recalls that curious snatch of dialogue in Lewis Carroll's classic book of nonsense, *Alice Through the Looking Glass*:

'When *I* use a word,' Humpty Dumpty said in rather a scornful tone, 'it means just what I choose it to mean—neither more nor less.'

'The question is,' said Alice, 'whether you *can* make words mean so many different things.'

Not only do those concerned with trees apply one name to several quite different species, but they will also—conversely—apply a variety of different names to one and the same kind of tree. A timber merchant will buy a tree as 'Scots pine' and sell it as 'red deal' or 'redwood', in much the same way as a butcher buys a 'sheep' to sell it as 'mutton', or maybe 'lamb'. In both cases the material changes its name as soon as it is cut up. But are such changes really necessary?

Yet there is a romantic story behind this chaos of nomenclature, the story of a language seeking to evolve new words to cover conceptions that were foreign to it. Four hundred years ago the English tongue included enough words to cover, without difficulty or confusion, the few score trees that were familiar to the English

people. But since then there has been a two-way traffic that has introduced these people to thousands of new trees for which no ready-made words could exist in their language. On the one hand, English-speaking people have gone out over the six continents and endeavoured to apply English names to the trees they found there; on the other hand, new trees have poured into English gardens and plantations, and new timbers into English warehouses, all clamouring for names that would sound well on the lips of English landowners or timber users.

It was beyond the power of the language to increase its stock of root-words by thousands to meet this situation. So makeshifts were adopted; existing tree names were combined with one another to produce such remarkable compounds as the 'hazel pine' (*Liquidambar styraciflua* L.) of North America, which is neither a hazel nor a pine; or adjectives were added so that a species of *Eucalyptus* (*E. fraxinioides* D. & M.) might pass as a 'white ash' in Australia. Occasionally the Englishmen who grew the new tree in their gardens would give it one name and those who imported it as timber would adopt quite another. For example, British botanists gave the conifer *Pseudotsuga taxifolia* Rehder, native to the Pacific coast of North America, the English name of 'Douglas fir'; but although this was accepted by British, American, and Canadian foresters, British timber merchants long retained their distinct trade name of 'Oregon pine' for the wood of the same tree.

Some of the advantages of a common language disappear when the same tree is known by different names in different countries; or the same word implies two quite different trees when used in two different lands. Moreover, the unravelling of this tangled skein of words and ideas has been a long and intricate business, accomplished only by the co-operation of the systematic botanists and wood anatomists of the several countries concerned. Here, however, we are concerned not with the consequences of this mix-up but with the way in which it arose.

Most of the English names applied to the common trees native to Britain are of Anglo-Saxon origin. These include: alder, apple, ash, beech, birch, box, elm, fir, hawthorn, hazel, holly, hornbeam, lime, maple, oak, pear, plum, whitebeam, and willow. All these trees are, of course, natives also of the neighbouring countries of continental Europe, and the immigrant Anglo-Saxons simply applied their own well-established names to trees that were already familiar to them in their homeland. It would be idle to speculate why a fifth-century Angle called a certain tree *aesc* (ash) and another *ac* (oak); such ancient folk-names probably arose when speech and the recognition of trees were both developing together. They are basic roots in the language, and so long as they are applied to the few botanically distinct species native to a relatively small land area such as the British Isles, they cause no confusion. In passing, nearly all these tree names of Anglo-Saxon derivation have cognate words in the other Teutonic languages of northern Europe—our 'oak' is the German *Eiche*, Dutch *eik*, Danish *Eg*, and Norwegian and Swedish *ek*.

Long before the Anglo-Saxons reached Britain the Gaels and Welsh who were established there before them had their own Celtic names for most of the native trees. But there was no need for the Anglo-Saxons to incorporate these Celtic

names into their speech, which already included equivalents for most of them. (Conversely, the Celtic peoples did not need to adopt the Saxon names, and the Gaelic and Welsh tree names continue in use to this day.) There is, however, one curious exception to this rule: our name 'yew' stems directly from the Welsh *yw* (and possibly the Gaelic *iubhar* also); there is said to have been an earlier English word 'heben' (cognate with the German *Eibe*), which went out of use in the sixteenth century.

To denote the rarer native trees, as well as those of early introduction, the English resorted to what the philologist terms 'loan-words', borrowed from other languages. Thus 'rowan' was adopted from the Danish *Røn*; 'chestnut' from the Latin *castanea*; 'plane' from the Latin *platanus*; sycamore from Hebrew *siqma* (an unrelated species of wild fig with which it became confused); 'service' from French *sorbier*; 'walnut' very probably from Dutch *walnoot*, signifying 'foreign nut'; 'larch' from German *Lärche*. 'Pine', which is derived either from the French *pin* (or *sapin*) or the Latin *pinus*, has supplanted the older English 'fir', which was previously applied to the 'true pines' of the genus *Pinus*. 'Spruce' is a loan-word with a singular history; it has no obvious connexion with the German *Fichte* or the French *pesse*; but it was the tree whose leaves were used to flavour spruce beer, and that beverage was so called because it was popular in the land of Spruce, an old French name for Prussia! 'Silver fir' is a literal translation of the French *sapin argenté*. 'Cypress' comes from Latin *cupressus*. 'Juniper' has associations with Italian *ginepro*, and also with gin, for which liquor its berries have long provided a flavouring; but its root is ancient Latin *juniperus*.

'Cedar' has a history as curious as that of 'spruce'. Its root is the old (Roman) Latin word *cedrus*, which implied the 'sharp cedar', *Juniperus oxycedrus* L., a shrub still called *cedro* in Italian. When the Scriptures were translated, this word *cedrus* was applied to the trees of the Lebanon Mountains of Syria; further translation from Latin to English created the word 'cedar', denoting these same trees; Linnaeus gave them the specific name of *Pinus cedrus*, and on this another botanist, Lawson, based a new genus called *Cedrus*; nowadays it is customary to call trees of that genus 'true cedars'. But where lies the truth—with Lawson, with Linnaeus, or with the Romans such as Virgil? It matters little, because in the English-speaking world 'cedar' is now applied to a wide variety of trees with fragrant wood. But when the Americans call their species of *Juniperus* 'ground cedars' they come nearer to the origin of the word than its parallel application to *Cedrus libani* Loudon, the 'cedar of Lebanon'.

As a rule, however, each fresh introduction of a foreign tree from Europe or Asia Minor was accompanied by a new root-word, so that little confusion resulted. 'Horse chestnut', of course, is the outcome of confusion between the Linnaean genera *Aesculus* and *Castanea*, due to the similarity of their fruits and seeds, but this is an exceptional case.

Thus far we have dealt with two sources of English tree names, the Anglo-Saxon root-words and the loan-words borrowed from the tongues of neighbouring peoples when the English first encountered, in or near Britain, new or unusual tree species. A third source arose when English-speaking peoples discovered trees

in overseas lands where their first contacts with the natives were hostile or unsympathetic. The main areas concerned are North America and Australia.

No doubt the North American Indians had good and sufficient names for most of their trees, but the early European settlers seldom adopted them. Instead they applied English names to the trees they found there, qualifying them with fresh adjectives. So we get 'red oak' and 'white spruce', and, since the principal genera of timber trees are the same in North America as in northern Europe, little confusion results.

In Australia, with its utterly different native tree flora, the result is less happy. Several species of *Eucalyptus* have acquired the name of 'oak' or 'ash', and a particularly absurd example of this misapplication of names is *E. gigantea* Hook. f., which is called 'Tasmanian oak' in some districts and 'alpine ash' in others!

A fourth source of tree names is the vernacular tongue of the natives of the overseas country in which the new trees are discovered. This source may be properly distinguished from the European loan-words, because at first the strange new name is only used in 'overseas English', and many years may elapse before it comes to mean anything in Britain. Well-known examples are 'kauri' in New Zealand and 'sal' in India. Problems arise when the range of an important tree is so wide that timber merchants and foresters have to handle it in countries with unrelated vernacular tongues. The Indian timber which now bears the British Standard name of 'gurjun' (several species of *Dipterocarpus*, with timbers so similar as to be interchangeable for all or most uses) is called 'hollong' in Assam, 'kanyin' in Burma, 'hora' in Ceylon, and 'yang' in Siam; the choice of 'gurjun' as its 'English' name is of course an arbitrary one. But nevertheless such vernacular names are generally to be preferred, for the excellent reason that at the time when the concept of a new tree enters the ken of the English-speakers, they bring a new root-word with which it can be expressed.

A fifth source is the tongue used by emigrants or traders of another European nation who happen to have got there first. Examples are most frequent in South America, where such timbers as 'santa maria' (blessed Mary) and 'quebracho' (from *quiebrahacha*, meaning 'break axe') acquired 'overseas Portuguese' names that have since found their way into English.

A sixth source lies in the inventive ability of the emigrants themselves. Thus, in Australia the terms 'ironbark' and 'blackbutt', descriptive words quite new to the English tongue, were coined to describe species of *Eucalyptus*. In South Africa, English immigrants thought up 'stinkwood', though perhaps that was borrowed from the Afrikaans 'stinkhout'. Even in Britain this capacity to think up an entirely new tree name is not quite dead, as witness our 'strawberry tree' (*Arbutus unedo* L.) and the popular name of 'monkey puzzle' for the Chilean conifer *Araucaria araucana* K. Koch. These invented names, however, are not new root-words in the strictest sense, but are derived from existing roots.

Now new words are excellent things when applied to new ideas, but the North American settlers were adept at applying them to existing concepts. They called the Englishman's poplars 'cottonwoods', his limes 'basswoods', and his horse

chestnuts 'buckeyes'—all good expressive words, but fruitful sources of confusion that need never have arisen.

A seventh source is provided by the scientific names invented by systematic botanists, who are obliged to use an artificial language to denote the various tree species accurately. An example is 'ponderosa pine' of western North America, which gets its forename from *Pinus ponderosa* Douglas. This is clear enough so long as the scientific name continues unchanged, but such a name is apt to be left unsupported if any such change ensues. For example 'insignis pine', which now implies *P. radiata* D. Don, arose when the botanical name of that species was held to be *P. insignis* Douglas. On the whole, it would be better to keep the two systems of nomenclature, English and scientific, quite distinct. The sort of confusion that can arise is seen when we consider *Chamaecyparis lawsoniana* Parl., which got its English forester's name of 'Lawson cypress' from the now obsolete scientific name of *Cupressus lawsoniana* Murray, and its American forester's name of 'Port Orford cedar' by analogy with the cedars of Lebanon. Now, say the botanists, it is neither cedar nor cypress!

The eighth and final source is the 'timber name', pure and simple, which although first used by timber merchants may eventually be applied by foresters to the living tree. A common problem here is that one trade timber may be drawn from several botanically distinct trees. Thus, some five species of *Swietinia* have an equal claim to be 'true mahogany', and several other quite unrelated trees are called 'mahogany' owing to a superficial resemblance to that wood. Sometimes a timber name conflicts with a tree name; for example 'redwood', used in the British timber trade for the wood of *Pinus sylvestris* L., is used in North America for the tree—and the timber—of *Sequoia wellingtonia* Seem.

It is important to distinguish these eight sources of English tree names, because each represents a more or less distinct group of English-speakers who had a sufficiently lively interest in trees or timbers to require words for their correct identification. To recapitulate somewhat, the Anglo-Saxon names were used by the first Teutonic immigrants; the loan-words for European trees probably arrived to a great extent on the lips or in the writings of monastic travellers. The names transferred from English trees to American and Australian species were first used in their new sense by pioneer settlers. The credit for the addition of overseas vernacular tree names to the English tongue belongs largely to Indian and colonial forest officers, who studied the speech of the peoples among whom their work lay. The names adopted from the Portuguese for South American timbers were, perhaps, first used by Englishmen in the days of the buccaneers. It was, again, the pioneer settlers of Australia and North America who thought up the 'invented' English tree names that characterize the floras of those countries. We return to Britain for the source of those English names that were derived from the Latin scientific names of the trees concerned; some of these names were coined by 'arm-chair foresters' who knew the trees only from botanical specimens or garden examples. Finally, the timber-trade names are the product of mercantile offices or warehouses.

Originally these words circulated in a relatively limited sphere. 'Alpine ash', for

example, was invented for use in Australia; and 'Oregon pine' for dealings between timber merchants in North America and their fellows in Britain. The members of the limited groups who used such words knew well enough what each term denoted. But with the growth of international trade, and interchange of ideas, it became necessary for members of each group to converse with those of other groups, and then this piecemeal evolution of tree and timber names, with all its drawbacks, became apparent. The British forester, the British timber user, and even, nowadays, the man in the British street, want to know why their 'Oregon pine' is not the same as their Scots pine; or how their own familiar ash differs from the Australian's 'alpine ash'. Rarely is any simple explanation possible. The builders of Babel were confounded by confusion of tongues, but confusion within what is outwardly one and the same tongue is, if anything, even worse. To show the difference between two trees that share the same English name it is usually necessary to refer to Latin!

This exposition of the ways whereby different interpretations of the same tree names arose may suggest, perhaps, how necessary it is to find some means of bridging the gulfs of misunderstanding that so frequently result.

In fact, a step in the right direction has been made by the British Standards Institution, who have issued lists of standard names for timbers. A parallel list, relating to home-grown timbers, has been published by the Forest Products Research Laboratory, Princes Risborough. But for this purpose a 'timber' is not always the same thing as a tree species; often one and the same timber name includes the woods of several species that may be quite distinct botanically and silviculturally. It is easy to imagine a list of 'standard names for trees' being drawn up, but much less easy to envisage its universal adoption among all the English-speaking peoples. For 'correct' English is mainly a matter of accepted usage.

In America a serious attempt has been made to produce a standard list of both common and botanical names for all commonly cultivated plants, and also for plant products such as timbers, drugs, and fibres. One object of this list is to clear up the multiplicity of names formerly favoured by nurserymen and gardeners in different parts of the United States. Under the title of *Standardized Plant Names*, it is sponsored by the American Joint Committee on Horticultural Nomenclature, a body which includes associations of nurserymen, horticulturists, and landscape architects, as well as the American Forestry Association; assistance in compilation was afforded by the United States Department of Agriculture and by senior officers of the United States Forest Service. Six years, from 1917 to 1923, were required to produce the first edition, and another five years, from 1937 to 1942, to revise the work for the second edition. The result is a quarto volume of 667 pages, which lists both common and scientific names, common synonyms and trade names, names for clones and varieties, and even the 'patented plants' which are a peculiarity of the United States. The names used by the American lumber trade for common timbers occupy a special section; but many of them differ from the recommended Standardized Plant Names. Even within America a native tree may have a 'forestry' name as well as a 'horticultural' one; a *Thuja*, it seems, is a 'cedar' in the forest but an 'arbor vitae' in the garden.

Although this list is useful as a work of reference for British foresters, the American *Standardized Plant Names* would be unlikely to secure general acceptance here. 'Scotch pine' falls a little oddly on ears accustomed to 'Scots pine'; and 'Douglasfir,' spelt as one word, looks somewhat strange in print; this amalgamation is insisted upon because it is held that Douglas fir is not a 'true fir'. But what *is* a 'true fir'? Historically the correct answer would be: a Scots (or Scotch) pine!

In conclusion the author invites attention to the practice that has grown up in British forest literature of denying English names to a small group of North American conifers which we are planting in our woods on quite a fair scale. All these trees have accepted English names in North America, and in Britain a lead has been given by the adoption of these North American names in Bulletin 14, *Forestry Practice*, of the Forestry Commission. The trees concerned are:

Abies grandis Lindley = Grand fir
A. nobilis[1] Lindley = Noble fir
Thuja plicata D. Don = Western red cedar
Tsuga heterophylla Sarg. = Western hemlock.

It is time that foresters dropped the recourse to Latin (and italics) that arose when these trees first arrived as rarities from the arboreta. This is not, of course, to imply that they should be denied their scientific names in a proper context, but such a list as

'Scots pine, *Abies nobilis*, and Norway spruce',

is illogical and might well be redrafted.

There are, no doubt, other trees that will become accepted in course of time as common 'English' trees in the same way as the introduced larches and walnuts. Each in turn might acquire with advantage a 'standard forest name' which would be, wherever possible, the same as the standard name of its timber; and also, especially where the tree is brought in from an English-speaking country, agree with the name that foresters give it in its native land.

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[1] *Abies nobilis* is now considered an obsolete name by the systematists, who prefer *A. procera* Rehder. This reinforces the case for adopting an English name, which might well prove less subject to such sudden changes.

SOCIETY'S AND OTHER NEWS

EXCURSION AND ANNUAL GENERAL MEETING, 1951

The Society will celebrate its semi-jubilee by an Excursion centred in Oxford where its first constitution was adopted. The 24th Annual General Meeting will be held during the Excursion. Further details will be issued as soon as practicable. Provisional arrangements are as follows:

September 24th. Gather at St. John's College, where accommodation has been reserved for up to 80 people. Arrangements will be made for those members who wish to visit Alice Holt Research Station on the 24th.

September 25th. Inspect new buildings at Imperial Forestry Institute. Visit Bagley Wood and Kennington Nursery. Semi-jubilee dinner to be held in Oxford.

September 26th. Visit Earl Bathurst's estate, Cirencester. Annual Meeting and discussion.

September 27th. Forest Products Research Laboratory, Princes Risborough, and, if possible, Hampden Estate, Buckinghamshire.

September 28th. Disperse.

CHANGES OF ADDRESS, ETC.

Members are reminded of the importance of intimating changes of address and rank, &c., to the Secretary so that records may be kept up to date. All correspondence for head-quarters should be addressed to the Secretary, Society of Foresters of Great Britain, 7 Albyn Place, Edinburgh, 2, and not to an individual by name. This is to save confusion with other bodies at the same address.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The Annual Meeting in 1951 will be held in Edinburgh from August 8 to 15. Sir Henry Beresford-Peirse, Bt., Director of Forestry for Scotland, is Chairman of the Forestry Sub-Section, and a full and interesting programme is being arranged.

THE SOCIETY'S MEDAL

The medal awarded to Sir John Stirling-Maxwell, Bt., K.T., of Pollok, at the 23rd Annual General Meeting was formally presented to him by the President and Sir Henry Beresford-Peirse on the 2nd of February 1951.

HONOUR

The award of the C.B.E. in the New Year Honours List to Mr. W. H. Guillebaud, Deputy Director-General, Forestry Commission, is a welcome recognition of his great services to British Forestry. The award gives particular pleasure to this Society for which Mr. Guillebaud has done so much.

THE LATE SIR ALEXANDER RODGER, O.B.E.

Sir Alexander Rodger died at Forres on the 30th September 1950, at the age of 75.

After Cooper's Hill, he entered the Indian Forest Service and his sphere of activities alternated between Burma, to which he was posted first, and Dehra Dun. In 1925 he was appointed to be President of the Research Institute and College, Dehra Dun, and in the following year became also Inspector-General of Forests. During his period of office the present Forest Research Institute building was completed and opened.

On his retiral from India in 1930 he took an active part in British forestry. He was President of this Society in 1934 and 1935, Chairman of the Forestry Sub-Section of the British Association in 1931, and a Forestry Commissioner from 1932 to 1942. Until the mid-war period, therefore, he was in close touch with forestry in this country, and his wide knowledge and experience was available during the inter-war period in the development of forestry in this country.

He had an attractive personality, solid, candid, and without frills. He loved the countryside, and if the woods had any rival in his affections, it was the rod and the pool. His friends will regret sincerely his passing and cherish his memory.

H. M. S.

EXCURSION TO ARGYLL

25th to 29th September 1950

About fifty members met at Oban whence visits were made to the State Forests of Inverliever and Barcaldine, and to two private estates, Cumlodden, the property of Sir George Campbell of Succoth, Bt., and Inveraray, under the charge of the Trustees of the Tenth Duke of Argyll. The Society thanks the organizers, the two private owners, particularly Sir George Campbell, and the Forestry Commission, for the hard work done and the help given to make the excursion a success.

The retiring President (Mr. O. J. Sangar) addressed the Society at the Twenty-third Annual General Meeting on the 26th and this address is printed on another page in this *Journal*. The evening of the 28th was devoted to a discussion on the principal items of interest seen. At this last meeting, at the suggestion of the new President (Professor H. M. Steven), and by general agreement, a message of good wishes was sent to Sir John Sutherland informing him that the Society had that afternoon visited the fine grove of Douglas fir named after him in Barcaldine Forest.

Inverliever State Forest

Visited on the 26th September in most perfect weather. The forest is situated on the west side of Loch Awe, and the land was acquired by the Office of Woods in 1907 for large-scale afforestation as typical of large areas of land in the west of Scotland. Planting went on annually from 1909 to 1928. Altogether 2,650 acres have been planted, of which 75 per cent. is Sitka and Norway spruce (*Picea sitchensis* and *Picea abies*). Other species used on the better class soils are European and Japanese larch (*Larix decidua* and *Larix leptolepis*) and Douglas fir (*Pseudotsuga taxifolia*), with small quantities of *Abies nobilis* and *Thuya plicata*. *Abies alba* was tried and failed through attacks of *Adelges*. A most interesting stage has now been reached in what is a remarkably successful piece of afforestation. Thinnings began in 1937; during the war years the stands on the lower lochside slopes were thinned frequently, often annually. Thinnings are now being done on the higher, less accessible areas with a view to bringing the forest to the stage when the original plan can

again be put into operation. At present there is a 3-year thinning cycle and the principal point discussed was whether this could be changed safely into a 4-year cycle with the consequential increase in intensity. The reason for the desired change was a management one. The nature of the terrain, the high rainfall, and available road system all make extraction very difficult, while the labour supply is barely adequate. A lengthening of the cycle would assist. On the other hand, the rapid growth on the better sites will necessitate heavy thinning, if the cycle is increased, and there may be a risk of windfall. Two private firms of timber merchants are operating, in the north and south ends of the forest respectively, and tribute was paid to their efficiency. Additional housing is almost ready. The general consensus of opinion was that the cycle could be increased safely to 4 years. The special problems of extraction are referred to in the report of the Technical Discussion.

Inveraray and Cumlodden Estates

Visited on the 27th September. The morning was very wet, but the weather improved towards the afternoon. The party travelled to Inveraray via the Pass of Brander and Dalmally and returned via Lochgilphead. Sir George Campbell met the party at Inveraray and gave his entire day to the visit. The party was shown first remarkable groups of *Thuya plicata*, *Tsuga heterophylla*, and *Abies grandis* 65 to 70 years old, which are thought to have been planted by the late Mr. James Grant. The groups illustrated well how such marked shade-bearers could thrive without attention. No thinning had been done and the *Tsuga* was remarkably free from buttressing. There was some interesting seedling regeneration near by of *Tsuga*, *Picea*, and *Abies*.

The reafforestation scheme on Cumlodden started in 1919. To date 378 acres, out of a total of approximately 500 acres which it is hoped to dedicate, have been planted, and all outstanding heavy timber, the remainder of the previous sporadic plantings, were felled during and since the war, so that the forest in course of establishment contains nothing older than 30 years. Despite this fact, from 1939 to date 105,000 cubic feet of thinnings have been produced. Rabbits are under control and all planting has been done without wire, but roedeer (*Capreolus capraea*) are rather troublesome. Thinnings are marked, felled, and snedded by estate labour, and sold to the merchant at stump. The very interesting and beautiful woodland garden on both sides of the Crarae burn was laid out and planted when Mr. Dalgleish was Head Forester. It contains plots of ninety-three different kinds of conifers. A further account of the visit to these two estates, written by Professor Steven, has been published in *Scottish Forestry*, vol. v, No. 1.

Barcaldine State Forest

Visited on the 28th September in reasonably fine weather. The forest was approached from the Loch Creran side. Barcaldine, which lies along the south shore of Loch Creran, was acquired in 1924. There are now about 2,900 acres of young conifer plantations, much of which were made on ground covered with scrub oak and birch. This was first heavily thinned and later the remainder was girdled (some say too early). Some of the earliest Forestry Commission trials of turf-planting were made here. There are still about 1,000 acres of bare land to be afforested. A plantation of hybrid larch (*Larix eurolepis*) of excellent form was seen and a very successful stand of *Picea omorica*, with its typically narrow form, planted on the sourest of peat, in a frost hollow. The difficulty at present about this spruce is the shortage of seed, but as this species, like most others, has coned freely in Britain this year, there is prospect of some home supples. Two plots of a plantation of Sitka spruce marked and felled for a first thinning, one of the usual intensity and one heavier, led to considerable discussion. The general opinion was that the heavier thinning,

in which 23 per cent. of the standing volume was being removed, was about right for a 4-year thinning cycle (see also under Inverliever). The party was also shown a fine group of about forty Douglas fir, on river gravel (Sutherland's Grove), planted about 1870, from seed collected from the Taymont Douglas which were themselves planted in 1850. The origin of the Taymont Douglas is unknown but the form is excellent. The party then proceeded to Loch Etive along the road following Glen Saloch, pausing on high ground to get a panoramic view of the planting of 1931 to 1934, where factors influencing the selection of species were explained and discussed.

Technical Discussion

The bearing which the fast growing conditions seen in the last few days had on (1) choice of species, (2) spacing, (3) thinning, (4) pruning, (5) timber quality and ring width, and (6) extraction, was chosen as the subject for discussion, and an extremely well-handled and keen discussion ensued. Mr. J. E. James, who had ably borne the brunt of the visits to the two State Forests, outlined the main factors guiding the choice of species in afforestation on the west coast. Vegetation types were useful if proper regard was paid to the vigour of the herbage. Bracken (*Pteris*), however, was too widespread to be reliable without soil study. Drainage and exposure were both important. Failure to allow for biotic factors such as the effect of past grazing or of burning might cause mistakes. With the high rainfall, spruce was the first choice; Norway spruce on sites not unduly exposed with *Juncus*, *Myrica*, *Molinia*, &c.; Sitka spruce on the foregoing sites if exposed and on the sourer peats with *Molinia*, *Calluna*, and *Scirpus* but confined to frost-free areas. *Picea omorica* had a special use in frost hollows. *Pinus sylvestris* was used on the knolls indicated by *Calluna* and *Erica cinerea*; *Larix* on the fresher mineral soils and drier slopes in this high rainfall region; Japanese larch where rather moister or more acid conditions prevailed, and hybrid larch intermediate between European and Japanese; *Tsuga*, *Thuya*, and *Abies grandis* and *nobilis* in small quantities on the better mineral soils. In the discussion which followed there was general agreement that in first-rotation afforestation the primary object must be to find something that would grow.

The balance of opinion on spacing was that while rapid growth justified some wider spacing and economy of plants, it was dangerous with spruce to plant so widely that pruning became essential.

The discussion on thinning was confined to the silvicultural side of thinning fast-growing Sitka spruce, management being disregarded. Mr. Garthwaite would thin first when the dominants were 28 to 30 feet high, or 25 feet on peat. The spruce seen that afternoon had been left until the dominants were 44 feet high. Mr. Zehetmayr said that we had research plots for thinning before the canopy closed, combined with pruning. We should eventually therefore get the answer. Several others spoke, and the sense of the discussion on the whole supported the rather bolder lines now being adopted, as seen in the more heavily thinned plot at Barcaldine that afternoon.

Mr. Zehetmayr, who had at Inverliever demonstrated the research methods adopted in the green-pruning of Douglas fir, suggested some general rules for pruning which started discussion, but it was felt that there was risk and possibly little financial gain in pruning spruce, and with so much else to be done it was better left unpruned.

On the matter of timber quality and ring width Mr. J. T. Smith wondered whether we were looking too much at the past. Possibly not more than one-third of our trees would be wanted for timber. For timber, grading was admittedly on knots, and ¾-inch knots and not too many of them was the maximum for first grade. There was little first grade in home-grown timber. Mr. C. W. Scott cited Benson H. Paul and his colleagues at Madison

as favouring four rings to the inch as the minimum for safety with pitch pine (*P. palustris*), and in addition there should be uniformity from core to exterior of the log; he said that in South Africa Dr. Craib and his co-workers agreed in general but aimed at six rings. Experiments were under way at Princes Risborough on this matter. Day at Oxford was doubtful whether some races of spruce were forming enough summer wood in each annual ring. He (Scott) did not agree that it would pay to disregard quality. Provided we watched uniformity of ring width, and average density, we should be all right and get fair quality at short rotations.

Mr. J. T. Smith regretted that there was no timber merchant present with recent experience of extraction in the west of Scotland. Things had changed greatly. The freight by sea to Glasgow used to be 10 shillings a ton. He had played with ropeways and found them expensive. Mr. Riddoch, although an advocate of road systems, agreed that in the west it was sometimes difficult owing to rock, peat, and water. The importance of a suitable road grid was stressed by Mr. W. A. Robertson and by Sir Harold Glover. Temporary roads of spruce brushwood and corduroy were mentioned by Mr. Oliver. Mr. Garthwaite said that at Keilder, Northumberland, rackways on the herring-bone system had reduced the distance from stump to wheel sometimes to as little as 30 yards. Professor Mobbs suggested partial conversion at stump—a point taken up later by Messrs. Smith and James on the possibility of peeling and drying at stump, which it was thought would take too much labour—and secondly the value of contour paths constructed for inspection and used later for extraction; thirdly, the need to give sufficiently concentrated work to the contractor, a point which tied up with the thinning cycle and the degree of thinning.

In summing up, Professor Steven said that at least we had solved the problem of growing timber on many sites in the west, and for this great credit was due to the pioneer work of the late Mr. James Murray. At Inverliever under present conditions the difficulty of extraction cancelled out the advantage of fast growth. The next task was the solving of these difficulties, and a large-scale investigation was needed, including trial of the Wyssen cable system.*

* An acccount with photographs of the Wyssen cable system in use in Switzerland was written by Col. A. H. Lloyd, O.B.E., M.C., and published in the *Empire Forestry Review*, vol. xxviii, no. 4, of December 1949.

REVIEWS

Anatomy of the Dicotyledons, Leaves, Stem and Wood, in Relation to Taxonomy. By C. R. Metcalfe and L. Chalk. Clarendon Press, Oxford, 1950. 2 vols.; lxiv+1,500 pp.; 3 pls.; 317 figs. Price £6. 6*s*. net.

Review by B. J. Rendle

RESEARCH workers, lecturers, and others, vainly struggling to keep pace with a stream of original papers, are continually impressed with the need for authoritative digests or guides to scientific literature. They have reason to be grateful to those who take it on themselves to provide in summary form the distilled essence of a mass of original contributions.

The purpose of this two-volume work is succinctly stated in the Preface as follows: 'This reference book aims at providing a summary of our present knowledge of the anatomy of the vegetative organs of the Dicotyledons.' The authors have been conspicuously successful in their aim. Admittedly they were well qualified, by experience and circumstances, to undertake the task. They had each some 10 to 15 years of research behind them—sufficient to give them a mastery of the subject—and the prospect, all being well, of a similar period ahead in which to carry out the work. Furthermore, at the Royal Botanic Gardens, Kew, and at the Imperial Forestry Institute, Oxford, they had the requisite library facilities combined with access to a wide range of botanical material and unique opportunities for consultation with other botanists. Even with these advantages, to accomplish such a task during the intervals between ordinary professional duties in the course of a mere 10 years or so would be an achievement under favourable conditions. The fact that the book has in fact been written almost entirely during the war and the scarcely less difficult post-war period is a tribute to the zeal and perseverance of the authors and their co-workers. Incidentally it is pleasant to note that the assistance of the latter is acknowledged by their names being printed on the title-page.

It is more than 40 years since Boodle and Fritsch collaborated in the translation of Solereder's *Systematic Anatomy of the Dicotyledons*. Since that time a great deal of additional information has accumulated, as indicated by the bibliography of more than 2,500 references. In no aspect of plant anatomy has more progress been made than in the study of the secondary wood. Solereder's original treatise was weak in this respect, much of his information being based on the examination of small twigs. In the last two decades there has been a renewal of interest in vegetative characters as an aid to the accurate classification of the higher plants, which has focused attention on the need for a modern work of reference on this subject. In order to meet this need the authors have not only brought together the results of investigations published since 1908 and combined them with data recorded by Solereder, but each has contributed the results of his own extensive research. Moreover, much of their research has been specially designed to check doubtful points and to fill gaps in existing knowledge, and has been carried out concurrently with the writing of the book. The result is a more accurate, more comprehensive, and better balanced work than the original model.

The main bulk of the book comprises systematic descriptions of the families—or rather their histology—under headings such as Leaf, Young Stem, Wood, Root, and Anomalous Structure. The information recorded under these headings is essentially factual. For many of the families there has been added a section entitled Taxonomic Notes, summarizing

conclusions on the taxonomy of the family. The value of the descriptions is greatly enhanced by the excellent diagrammatic drawings of anatomical structure, most of which are original. Short notes on Economic Uses add to the usefulness of the book for purposes of reference.

Special mention should be made of the Introduction, in particular the sections entitled 'Anatomy and Taxonomy' and 'Anatomy and Phylogeny'. These 40 pages provide an admirable introduction to the study of systematic plant anatomy and ought to be widely read.

The historical development of botany has been such that anatomy and taxonomy have been more widely separated than they should be. There have been signs in recent years, however, that as taxonomists have learned the value of co-operation with cytologists and geneticists, so they are coming to appreciate the contribution which anatomists can make to their investigations. The potentialities and limitations of systematic anatomy are aptly summarized in the following extracts from the Introduction: 'The taxonomic value of cytological and genetical studies lies chiefly in the interpretation of species and groups of lower rank. Anatomical structure, on the other hand, is most likely to provide evidence concerning the interrelationships of larger groups such as families, or in helping to establish the real affinities of genera of uncertain taxonomic status. Anatomy is of restricted value for distinguishing species or groups of less than specific rank, because the differences between them are usually quantitative, rather than qualitative, and often demand statistical treatment based on a greater amount of material than is frequently available. Anatomy sometimes proves very helpful for individual identifications. Microscopical methods are of great value in establishing the identity of herbarium specimens unaccompanied by flowers or fruits, also commercial samples of medicinal plants, timbers, fibres, &c., and may play an important part in checking adulteration, substitution, and fraud.'

Limitations of space permit only a brief reference to the good work of the Clarendon Press. It must suffice to mention that the spacing of the sections, the well-placed cross-headings, and the skilful use of different kinds of type combine to achieve that high degree of visual clarity which is so important in a book of this kind.

Northern Coniferous Forest Soils: A Popular Survey of the Phenomena which determine the Productive Character of the Forest Soils of North Sweden. By Olof Tamm. Translated from the Swedish by M. L. Anderson. The Scrivener Press, Oxford, 1950. 17*s.* 6*d.*

Review by G. K. Fraser

DURING the past half-century there has emanated from the forest research organizations of Sweden a steady flow of scientific investigation into the fundamentals of forestry, and for a somewhat shorter period a notable proportion of this has dealt with the problems of what is termed in German text-books *Standortslehre*, the science of locality or site, or, in its widest sense, of forest ecology from the practical aspect. Forest soil science is one of the basic subdivisions of this field study, and tends to become slightly modified pedology, agricultural chemistry, or such-like when, as frequently occurs, it is separated from its ecological context.

With Swedish forest soil investigation the names of Hesselman, Malmström, Romell, and, not least, Olof Tamm are internationally known for their contributions not only to forest soil science but to soil science in general; and to this list might be added the names of many well-known workers in more restricted branches of *Standortslehre*.

It is therefore with considerable pleasure that we welcome the rendering into English of Dr. Tamm's work on forest soils of north Sweden. In the work itself our expectations

are justified not so much because it fills a gap in the study of British forest soils, but because of the orientation of principle and thought which it presents. It is not to be expected that information on the forest soils of north Sweden can be directly applied to British forest practice, not only because of the differences which exist in conditions of tree growth and of soil formation, but also because so much of our most difficult contacts with soil take place, for example, in ground which has not for a long time carried forest growth, but is being reclaimed to forest from heath and moor which have been long subject to unnatural processes such as heather-burning and grazing. So also many of our crops are not indigenous species. But the central aim of the forest soil scientist and forester in both countries is the same, namely an understanding of the interrelations of the soil and the forest with a view to the classification of the soils on which forest grows or can be made to grow, and the ultimate estimation of their productive capacity whether natural forest or artificial. But the soil must be regarded as part of the *site*.

Because of its importance in agriculture, nutritional chemistry has tended in this country to be over-emphasized in soil science, in general obscuring the function of the forest soil worker as well as presenting to the forester tables of chemical data for which he can find only limited use. The forest soil scientist should be much more concerned with the general physical and ecological conditions of the soil, viewing the soil and its vegetation as part of a biological system of which the forest forms or will form a part, and in which climate, soil, and vegetation, including the trees, form one unit.

The outline of the contents of the book is as follows: The forest soil is derived from mineral matter and organic matter. The former is on the whole the basic soil material, the latter is superimposed on it during the biological history of the soil itself, and, as soil, both are a function of the local climate. Hence, in forestry, soil science cannot be kept distinct from the science of site-conditions, in which is considered as far as possible the whole complex of factors under which tree growth occurs at any particular place. The study of the forest soil is a biological study.

The growth requirements of the forest are then described, leading to the classification of the forest sites of north Sweden, under the term 'forest associations'. For the description of these, not only the forest crop but also the ground vegetation is used—e.g. the major associations are lichen forests, moss-*vaccinium* forests, *Dryopteris* forests, herbaceous forests, and swamp forests—each with subdivisions. The general relationships of these are sketched out (Chapters I and II).

In the next chapters (III-VII) those factors which interact to produce the characteristic forest sites and their associations are discussed in detail, namely, climate, mineral constituents, soil-producing surface deposits, and ground (i.e. bed-) rock, soil organic matter, and humus types.

In the following six chapters are described the north Swedish soils—their development, classification, and varieties; soil water; soil temperature changes; the types of organic deposits including peat, their various forms (e.g. mor and mull), and their importance in the forest associations in which they occur. This section contains much of what may be shortly referred to as the particularly Swedish contribution to soil science—for example, in Chapter XII the various forms of mor and mull are described and the interactions of organic cover and silvicultural practice are discussed.

In the last three chapters are discussed from a more definitely silvicultural aspect the development and characteristics of the north Swedish forest associations; their stability under treatment (Chapter XIV); their productivity and the influence of manuring on the soil (Chapter XV); and finally a survey of the practical classification of forest soils (Chapter XVI).

A very useful bibliography is given.

It is hoped that this summary gives an adequate idea of the scheme of the book. In the eyes of the British forester it is limited in extent—this, of course, because of the limited area dealt with. A similar account of the forest associations of Sweden as a whole would be invaluable to us.

All foresters and soil workers will feel indebted to Dr. Anderson for undertaking the labour of translation, but unfortunately, however adequate this has been on the whole, there are throughout many blemishes which could have been avoided by submitting his script to an independent reader. Most of these are of little scientific importance, but, for example, 'the northern forest's need of', &c., is not English, 'the soil liquid' is not an improvement on the 'soil solution', and so on. In general such renderings do not upset the meaning although their frequency does upset the reader. Here and there, however, the phrasing is definitely obscure—especially when technical description is involved, and at least in one instance the English conveys the opposite meaning to what was intended (the penultimate paragraph, p. 68).

Forest Types and Their Significance. By A. K. Cajander. *Acta Forestalia Fennica*, vol. 56. 1949. Helsinki. 71 pages in English with 4 diagrams.

Review by M. L. Anderson

TO those foresters who have made the acquaintance of the late Professor A. K. Cajander's standard work on *The Theory of Forest Types*, which appeared in English in 1926, the recent issue of an 'in memoriam' number of the publication of the Society of Forestry in Finland as a tribute to this remarkable man and outstanding forester will be most welcome. Not merely does this volume contain a biographical note detailing his career from 1879 to his death in 1943, a moving tribute by Professor Yrjo Ilvessalo to his late teacher, and a complete list of the 484 literary productions which were the result of Cajander's tireless labours; but it also contains in Finnish and English a reprint of a paper completed by Cajander four days before his death and published posthumously in that year in French in *Intersylva*, under the title of 'Nature et Importance de Types de Forêt'. This was itself a revised and enlarged edition of an earlier work which appeared in 1930 in German in *Silva Fennica*, entitled 'Wesen und Bedeutung der Waldtypen'. This work is therefore now available in four languages and was selected for the 'in memoriam' issue because it defines briefly and lucidly the essential principles of the forest type theory with which its author's name will always be associated.

The issue of *Intersylva* in question was published in Munich during the recent war, and Cajander ends his paper with an impassioned appeal for a renewal of international forestry relationships worthy of such a statesman. As the original paper is not readily available, the reissue of this masterly exposition is valuable and timely, no less for its technical matter than for the philosophical comments which reflect the character of its author.

The introduction touches upon the problem raised by specialization in the modern world and expresses views which will find an echo in many minds. The main body of the text begins with a closely reasoned discussion on the classification of forest sites and a comparison of natural methods of classification with those based on mensurational data hitherto so generally used. This is one of the best surveys of this important aspect of forestry available. The nature of vegetation units and forest types, and their value, when correctly appreciated, as indicators of site quality are then dealt with, and the system of Finnish forest types is given.

The practical significance of the forest types is that they provide a reliable basis for a preliminary classification of sites, which reflect, however, only the primary site factors,

since the types may suffer change through artificial modification of the mature stand. Once a means of recognizing them in any stage of their progress or regress has been found, however, they can be used as a basis for mensurational, silvicultural, and biological studies. This contention is supported by the yield-table data provided by Ilvessalo, by the stand structure studies of Lönnroth, and by the soil analyses of Aaltonen. The forest types can therefore be used to group forest stands into classes of equal biological value.

Probably the most important conclusion which Cajander reaches is that which he summarizes as follows: 'Systematic silviculture must thus be based on a full knowledge of the life-history of the forests and of their biology, and as the biology of forests is very different on different sites, it is obvious that silviculture must not become stereotyped, but must adapt itself to the conditions the different sites offer for the life of the forests, their renewal, growth, and development.'

It is stressed how great an influence the distribution of the natural forest types has had on the location of centres of population, not only in Finland but generally. The paper ends with instructions on how to establish forest types which it was no doubt the author's hope would encourage foresters to adopt his main thesis as the foundation of forest management and silviculture. This he doubtless felt justified in hoping on the basis of the studies carried out by some of his disciples in Canada, the United States, Switzerland, Esthonia, and Patagonia. In an appendix he suggests certain tentative forest types for Germany based on the result of some of his own visits there in 1906–7, hoping that they may provide a starting-point for a more thorough study of this question.

The ever-increasing bias towards the establishment of forestry on a biological rather than on a purely money-making basis, which is noticeable abroad and to a lesser degree in this country, is to a great extent due to the persistence with which Cajander has publicized his theory. The reviewer has on more than one occasion stressed the urgency of the need for some acceptable classification of site types in this country. It must be admitted that the problem of establishing a sound scale of site classes is much more complicated in the British Isles than in most other countries, but it only requires the general acceptance of the main principle to ensure that such a classification will in due course appear, probably having its own peculiar features but nevertheless relying to a great extent on work done in other European countries. When that time comes we shall not have forgotten pioneers in this field like Cajander, who, it is good to know, after venturing into the political field with all its disappointments, returned at the last to his first love and left us this last valuable contribution to forestry.

The Selection of Tree Species: An Ecological basis of Site Classification for Conditions found in Great Britain and Ireland. By M. L. Anderson. Foreword by Sir John Stirling-Maxwell, Bt., K.T. Pp. 151; 20 plates and index. Oliver and Boyd, Edinburgh. 12*s.* 6*d.*

Review by J. A. B. Macdonald

In a recent paper on agricultural ecology as a branch of science, Dr. Fraser Darling described ecology as the science of causes and consequences; the study of the organism in relation to its environment, finding and defining its niche. As the subtitle suggests, this new book is a treatise on practical forest ecology; some fifty different species of trees are the organisms concerned, the niches being the eighteen locality units which together constitute the author's scheme.

The book sets out to provide 'some relatively objective practical means of distinguishing and classifying plantable site-types, which will serve, not only as an aid in the choice of the

tree-species to be grown, but as a basis upon which a sound silvicultural practice can be built'. The reader gathers that the author is at least unhappy about the soundness of the selection of tree species in our generation, though the book is singularly free from anything in the nature of carping criticism. Such remarks as 'until it is appreciated that practice must often be varied with the site or locality conditions . . . sound development of forestry practice in the British Isles . . . will remain unduly retarded', may sound at first a little unkind to many individual foresters, who through trial and error, or the teaching of our best silviculturists—for instance the late Ray Bourne and Anderson himself—have altered practice with site in their own districts. Later on, however, Anderson does acknowledge that the best of our planters have allowed for locality variations. Obviously what he rightly has in mind is the lack of one comprehensive established system of site classification either within the country as a whole or within the Forestry Commission: in both spheres, as everyone admits, unfortunate choices of species and unhappy disregard for local variations have too often occurred.

The present book has grown up from the embryo, *The Natural Woodlands of Britain and Ireland*, produced in 1932, in which Anderson compressed into tabloid form for the forester's use much of the experience and knowledge of ecologists about our vegetation types and natural woodlands. During the intervening 18 years Anderson's experience of trees has widened and matured. He has had ample opportunity to test out his scheme and to revise it where necessary, which was indeed seldom. The result is still a small volume, but one which is unique in the amount of orderly wisdom and sound advice to foresters which it contains and expresses with, as Sir John Stirling-Maxwell points out, great simplicity and authority and clarity.

The book is in two parts: the first, occupying most of the book, deals with the correct appreciation or assessment of the locality factors.

Following the delightful 2,500-year-old quotation at the beginning: 'A gentleman takes as much trouble to discover what is right as lesser men take to discover what will pay', one is not surprised to find Anderson placing what is right and best for the soil first, and what will pay best or soonest far behind. 'The only safe basis for choice of species, especially in the creation of new forests, is the purely ecological one.' Practically the same argument is used by the agricultural ecologist Fraser Darling in the paper already mentioned. He says of ecological principles: 'at the present time we are in some danger of forgetting them, often because the demands of efficiency and mechanization call forth practices which produce results in a slick cost-account fashion to which our mind is admirably attuned.'

Fortunately, Anderson points out, the nature and composition of the living vegetation on a site is usually such that valuable inferences concerning the site can be drawn. He goes on to consider the other locality factors individually under: (*a*) *General* climatic conditions, (*b*) *General* configuration of the ground, (*c*) *Local* climatic variations, (*d*) *Local* topographical and soil variations, and (*e*) Inhibitory biotic factors.

In arguing the need for site classification Anderson mentions this country's remarkable omission 'to study typical optimal sites in their native habitats for the many exotic species which we so freely and often rashly use'. He points out that even Norway, where, compared with Great Britain, relatively little planting of exotics is done, has sent men to north-west America to study the native habitats of the conifers in which she is interested.

The advantage in dealing with vegetation as an aid to the selection of species on broad lines rather than intensively is again stressed in Chapter V, 'with a view to establishing a framework into which most of the more local types can be fitted'. Anderson here cautions the reader to beware of the changes to a plant community through grazing, burning, and similar biotic influences, and points out that this inconstancy, which makes the establish-

ment of a sound classification of waste-land communities difficult, has been responsible for some of the confusions and contradictions which have occurred. He classes as unsatisfactory the attachment of too great a significance to certain conspicuous but unsatisfactory plants such as ling (*Calluna*), bracken (*Pteris*), and molinia. Where these are dominant it is important to pay more attention to their associates, seemingly secondary species. The actual table, showing his classification into eighteen plant community/locality units, comes in Chapter VI, and each one is described.

Then follows an examination of the tree species available, a discussion of the qualities which render introduced species desirable, and a classification of all the species according to use, viz. timber producers, soil improvers, pioneer or nurse trees, storm-resistant species, fume- and salt-spray-resistant species, and lastly underplanting species.

In studying the list one has constantly to remember that it is intended to cover the general and very wide range of locality conditions; for instance, accustomed to work mainly on the poorer sites, it surprised me to see Scots pine listed as storm-resistant and resistant to atmospheric impurity and salt spray. Again with the poorer land in mind, I was astonished to see birches listed as soil improvers and pioneer or nurse crops (we have to nurse birch on the poorer heaths and moors), but it delighted me to find Douglas fir among the soil improvers.

Chapter VIII is devoted to the fifteen natural forest types of the British Isles, and Chapter IX to the most comprehensive and most excellent summaries of the salient features of the broad-leaved species. Knowing the writer's interest in the oaks, I wonder how many readers will, as I did, make straight for sessile oak? As expected, he gives it pride of place: 'The most important British and Irish forest tree.' This chapter includes notes on the three most promising Eucalypts.

Chapter X deals with 23 conifer species, commencing with Scots pine and finishing with *Sequoia sempervirens*. It was pleasing to me to read of the coastal type of *Pinus contorta*. 'Its capacity to resist extreme exposure, especially from salt-laden winds, and to grow rapidly on the very poorest of soils, and the improving effect of its heavy litter layer, make it the supreme pioneer species for western districts.'

The final Chapter (XI) of Part I presents a table in which the more important trees are grouped in two columns, 'hardy' and 'tender', within the eighteen site classes.

Part II (Making the Selection) is one very short chapter in which the author shows, after giving due weight to biological, economic, and special considerations, how the process of selecting the species to be planted is completed with the help of the classifications worked up in Part I.

This section contains a tremendous concentration of 'meat' and would alone be worth many times the price of the book, especially to landowners intending to plant. There are two observations to make on this section, which seems otherwise very sound. The first concerns birch and alder, which are so freely advocated even for nursing such fast-growing conifers as Sitka spruce. On some locality types in southern and Irish districts the use of birch, &c., as a nurse may be necessary, but it is difficult to imagine any site in the northern half of Britain where Sitka spruce would not soon smother out such nurses unless in frost-hollows or frost-flats or in some other peculiar circumstances which ought to have been specified. Possibly the word 'nurse' is not restricted to the initial establishment phase but is intended to cover the natural regeneration stage a whole rotation farther on; in any case a little more explanation would have been reasonable. The second concerns Anderson's quite arbitrary condemnation of his F3 '*Sphagnum*-moor, or *Calluna*-moor Community': I can think of more than one such site which I should like to show Anderson, where trees are growing steadily at 25 years of age.

A minor criticism is the over-frequent use of symbols such as B_2, C_3, instead of simple explanatory titles such as Fern type and Sedge type for the eighteen locality units. Again, simpler titles might have been chosen for Part I and Part II which would have been less awe-inspiring to the ordinary forester and every bit as descriptive.

Foresters who know Dr. Anderson well, especially those who developed affection and regard for him when fortunate enough to be his pupils or his juniors, realize the extraordinary intensity of his interest in forestry, the scope of his powerful mind, the depth of his learning, his thoroughness, and his unequalled capacity for study and painstaking work. These foresters especially will be glad to have this record of his reasoning and experience although they may be just a little disappointed by the suppression of the violent criticism and complaint which they learned to appreciate, knowing well that the genial spirit and sparkling humour were not far beneath. No one will deny that this is one of the outstanding British forestry books of the century and is a practical manual of great value.

Textbook of Dendrology, covering the Important Forest Trees of the United States and Canada. By W. H. Harlow and E. S. Harrar. Pp. xiii, 555. McGraw-Hill Book Company, Inc., New York. 1950.

Review by F. K. Makins

DENDROLOGY is a word not used in Britain. *Chambers's Dictionary* defines it as 'the natural history of trees'. In their Introduction the authors state that 'dendrology means the study of trees, but through common usage it has come to signify the taxonomy of woody plants including trees, shrubs, and vines'. The emphasis, therefore, is on classification, nomenclature, and identification. The rules revised at the Sixth International Botanical Congress at Amsterdam in 1935 have been generally followed, though specific epithets have always been made to begin with a small letter. Aids to identification stop short at family and generic characters—a wise precaution in view of the acknowledged incompleteness of the work—but there are useful tables setting out the distinguishing characters of the more important species.

The Introduction gives a series of clear and useful diagrams of leaf shapes and margins, flower structure and arrangement, various types of fruits and seeds, twig features, and a profile of the Sierra Nevadas showing the effect of elevation and rainfall upon forest distribution. There is also an excellent photograph of a relief map of North America.

The main part of the book is taken up with descriptions of the most important families, genera, and species, illustrated with good photographs and small distribution maps. The sequence followed is that of Engler and Prantl. There are numerous notes on cultivation and timber.

The pines have been classified into Soft and Hard Pines. In the Soft Pine group the three well-known White Pines, *Pinus strobus*, *P. monticola*, and *P. lambertiana*, are described in detail, and of the Hard or Yellow Pines *P. resinosa*, *P. rigida*, and *P. banksiana* of the north-eastern States and Canada, and *P. palustris*, *P. echinata*, *P. taeda*, and *P. caribaea* farther south, are given prominence. These ten, together with Western Yellow Pine (*P. ponderosa*) in the north-west, are evidently the most important pines in North America. *P. ponderosa* var. *Jeffreyi* is now promoted to specific rank as *P. Jeffreyi* A. Murr. since the bluish-green twisted needles, longer cones, and resin-free buds appear to be constant characters. On the other hand, *P. contorta*, which is used in Scotland as a nurse on wet or difficult sites, is dimorphic in the U.S.A., the inland mountain form being straighter and taller and with needles of a lighter shade of green. This variety was formerly known as *P. murrayana* Balf. but, as the authors point out, the two varieties cannot always be

distinguished. We recently came across a single specimen in a wood in Dorset and had some difficulty in identifying it. The correct name of the mountain form is now *P. contorta* var. *latifolia* S. Wats.

We are told that European and Japanese larches are used for reafforestation in the eastern States but there is no description of either, only a small photograph of the flowers of *Larix decidua*.

Norway spruce (*Picea abies*) has been also widely used in forest plantations, especially in the east, where it is said to grow faster than the native spruces though less hardy and tending to die at the top when 60 to 70 years old.

We agree with the authors that the shorter glaucous variety of Douglas fir is not a distinct species and that the researches of Henry and Flood were not conclusive. There is no mention of Fraser River Douglas fir, such a bugbear to amateur foresters in Britain, and which we consider to be a local form probably intermediate between the green coastal and inland glaucous forms.

The Sequoias are pictured in a coloured frontispiece as well as in the text. The authors have not adopted the latest name *Sequoiadendron giganteum* (Lindl.) Buchholz for *Sequoia gigantea* (Lindl.) Decne., both referring to our familiar planted Wellingtonia.

The authors modestly admit that several families and many genera and species of broad-leaved trees have been omitted. It is true that only two hybrid poplars, Lombardy and *P. eugenei*, have been mentioned at all, but the book is mainly concerned with introducing to students of forestry the commercial species of North America. The Red Oak commonly planted in Britain and known here as *Quercus rubra* is fully described and illustrated as *Q. borealis* Michx. f., which the authors state to be 'probably the most important and widespread of northern oaks'. Since the similarity among the young leaves of the various species of Red Oak planted in Britain causes much confusion, the tables given on pages 346 and 347 and the clear illustrations which follow are a great help. *Q. rubra* L. is identical with *Q. falcata* Michx., while *Q. rubra* Du Roi is *Q. borealis*. *Q. falcata*, which is not often seen in Britain, is readily identified by the grey or tawny pubescence on the under surface of the leaf.

The thoroughness of treatment and the beauty of the illustrations are praiseworthy. The photographs are not quite up to the standard of R. B. Hough's book, already reviewed in this journal, but in other respects the work is unrivalled.

At the end are a glossary, a comparatively short list of derivations of scientific names, 315 selected references, and a good index.

The book is well printed and strongly bound. It is good value for five dollars.

NOTICES

Journal of Forestry. Vol. 48, No. II. November 1950.

THIS issue celebrates the fiftieth anniversary of the Society of American Foresters of which it is the official organ, and is dedicated 'with respect and affection to those founding members whose vision and labors created the profession of forestry'.

It is dedicated also 'to the younger generation of foresters and those now entering the profession, in the confident expectation that they, no less than their elders, will advance the objectives and standards of forestry for the national welfare'. Remarking that it is a far cry from 1900, when the seven charter members led by Gifford Pinchot held the initial meeting in Washington, to the well-organized body of today with a total membership of 6,899, an historical survey traces the progress made by the Society during the fifty years and ends by summarizing a 'few of the things which stand to the credit of the Society' and which have brought it to its present honourable position 'as the national body which represents the profession of forestry in the United States'.

We offer our congratulations to the Society of American Foresters on its anniversary and our best wishes to the Society and to its *Journal* for the future.

Journal of the Oxford University Forest Society. Michaelmas Term 1950. Third Series. No. 5. The Holywell Press Ltd., Oxford. *7s. 6d.*

THIS issue contains some excellent material, including an account of the opening of the new Institute by H.R.H. Princess Margaret and an account of the timbers used in the building, an article on road building in Malaya, a note on the Brandis system of yield regulation, and accounts of forestry in New Zealand, Austria, Malaya, and Kenya. The Society's finances are causing alarm and an appeal is made to life-members for help so as to maintain the size and quality of the *Journal*, the cost of producing which is three times that of 1938.

CONTENTS

Speedier Rehabilitation of English Woodlands. By O. J. SANGAR . . . 1
A Fallacy in the Theory of Growing Stock. By R. BOURNE 6
The Possibilities of Improving Forest Trees (*with Plate I*). By C. SYRACH LARSEN 19
A Study of Growth Rings in Trees. By C. G. DOBBS 22
A Century-old Forest Nursery in Germany (*with Plate II*). By BLANCHE BENZIAN 36
The Susceptibility to Injury by Experimental Freezing of Strains of European Larch (*Larix decidua* Mill.) of Varying Geographical Origin. By W. R. DAY 39
English Tree Names and their Origins. By H. L. EDLIN 57
Society's and Other News 64
Obituary. The Late Sir Alexander Rodger, O.B.E. 65
Excursion to Argyll 65

REVIEWS

Anatomy of the Dicotyledons, Leaves, Stem and Wood, in Relation to Taxonomy (C. R. METCALFE and L. CHALK). By B. J. RENDLE . . . 69
Northern Coniferous Forest Soils (OLOF TAMM, translated from the Swedish by M. L. ANDERSON). By G. K. FRASER 70
Forest Types and Their Significance (A. K. CAJANDER). By M. L. ANDERSON . 72
The Selection of Tree Species (M. L. ANDERSON). By J. A. B. MACDONALD . 73
Textbook of Dendrology, covering the Important Forest Trees of the United States and Canada (W. H. HARLOW and E. S. HARRAR). By F. K. MAKINS 76

NOTICES

Journal of Forestry. Vol. 48, No. II. November 1950 78
Journal of the Oxford University Forest Society. Michaelmas Term 1950. Third Series. No. 5 78

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